WORLD PETROLEUM

IN TWO SECTIONS
SECTION ONE

JUNE 1959

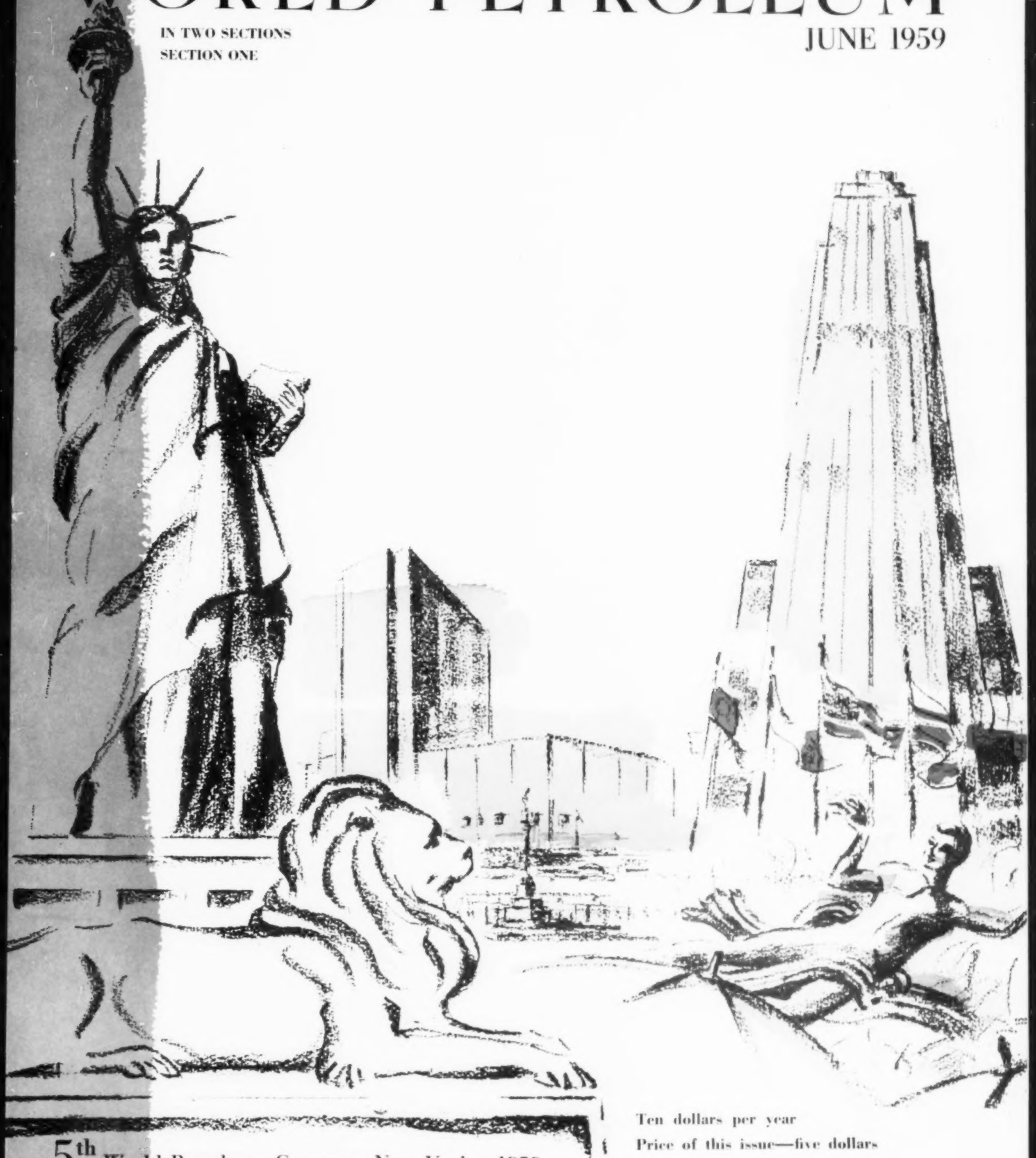

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Table of contents page 3

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VOL. 30, NO. 6, JUNE, 1959

CONTENTS

SECTION I

6 Washington Pipeline, *by Joseph B. Huttlinger*

8 What Happened at Cairo, *by Jean Jacques Berreby*

12 London Letter, *by Cecil W. Wood*

57 Editorial

58 Change and Growth, *by Frank M. Porter*

60 Who's Who at the World Petroleum Congress

62 The High Cost of Whale Oil, *by Kendall Beaton*

68 Canada's Bright Future, *by W. M. V. Ash*

70 Oil's Contribution to the British Economy, *by C. M. Vignoles*

74 Oil's Secret, *by S. S. Smith*

78 Golden Jubilee of BP

84 100 Years of Oil Refining, *by Harold S. Bell*

93 60 Years of Oil-Field Experience,
by A. Beeby-Thompson, OBE

104 Natural Gasoline, *by Charles E. Webber*

114 Shell's Contribution to the UK Petroleum Chemical Industry

118 100 Years of Oil Production, *by Dr. Lester C. Uren*

134 Marketing . . . From Coal Oil to the Petroleum Molecule,
by V. B. Guthrie

148 Royal Dutch/Shell Since 1955

156 Kuwait Oil Co.'s North Pier Project

160 Shell Research in the United Kingdom

164 Four Decades of Petrochemicals, *by Peter W. Sherwood*

172 British Petroleum Equipment

176 100 Years of Oil,
by Neil P. Hurley, SJ, and Sebastian J. Raciti

220 The Free-Piston Engine, *by Donald H. Robson*

227 101 Years of Canadian Oil

234 International News and Notes

254 Oil Company Staff Changes

255 Latin American Oil News

256 Advertisers' Index

SECTION II

Oil in Western Europe

1 Introduction *by Paul Finet*

2 The Federation of Petroleum Equipment Manufacturers
by J. P. Le Gall

3 Trends in Oil Economics and their Influence on the European Energy Market *by Lucio Corradini*

Austria

2 Introduction *by jur. Fritz Bock*

3 Foreword *by Dr. H. Kern*

3 History of Petroleum Exploration in Austria *by Prof. Dr. H. Kupper*

4 Austrian Oil Administration

10 Outline of Oil Geological Conditions in Austria *by Dr. R. Grill*

14 Turbodrilling *by H. Rietsch*

15 Drilling and Producing Techniques *by V. Gerzabek and H. G. Ulrik*

18 The Graz Basin *by Dr. R. Janoschek*

20 Petroleum Transport on the Danube

23 Two Stroke Engines for Heavy Duty *by Dr. Ing. Robert Sollner*

28 Quality Aspects of Sucker Rods *by H. Bouresny*

34 Austrian Refineries *by Dipl. Ing. E. Hammer and Dipl. Ing. R. Wallner*

36 Use of Natural Gas *by Dr. Ing. F. Huber*

36 Natural Gas Production *by Dipl. Ing. M. Hirsch*

Belgium

2 Belgian Economic Interest in Petroleum Industry Development *by Baron Snoy et d'Oppuers*

3 Belgian Participation in the Fifth World Petroleum Congress *by F. P. Malschaert*

4 Petrofina—A Financial and Industrial Group *by G. Van de Put*

6 Public Knowledge of the Oil Industry Promoted by Groupment Petrolier

8 Petroleum and the Belgian Construction and Oil Equipment Industries *by Prof. Dr. Gaston Craen*

10 Belgian Council of Manufacturers of Equipment

France

3 Oil and The French Economy *by Jean-Marcel Jeanneney*

5 La Chambre Syndicale *by Henri Ballande*

6 Contribution of the Institute Francais Du Petrole to the Petroleum Industry *by Rene Navarre*

9 Bureau De Recherches Du Petrole *by Yves Delavesne*

11 French Petroleum Equipment *by Georges Perret and Guy Henry*

15 The Importance of Saharian Oil *by V. de Metz*

19 C.R.E.P.S., a Sahara pioneer *by Paul Moch*

23 History of S. N. Repal Geological Exploration *by Roger Goetze*

25 Lacq Gas as a Factor of French Economic Prosperity *by Andre Blanchard*

33 More Efficiency and Lower Drilling Costs *by J. Gallon*

34 Latest Developments in the Field of Electrical Measurements in Drill Holes *by J. L. Mathieu*

41 The French Petrochemical Industry from Petroleum to Refining and Chemistry *by Maurice Moulin*

47 The Pipeline in the French Petroleum Industry *by Andre Genthial*

43 Gas Piping Networks in France *by Pierre Courtet*

55 Why the French Built the World's Largest Truck the T 100 *by Paul Berliet*

Germany

3 Foreword *by Ludwig Erhard*

6 Oil Training in Germany *by Dr. H. C. Gunther Schlicht*

12 Production in Germany *by Dr. H. Pfefferkorn*

19 Types of Oil and Gas Deposits *by Dr. F. Kuhne*

30 Application of Diamond Bits to Turbine Drilling *by H. J. Weimann*

46 The Max Planck Institute *by Prof. Dr. Karl Ziegler*

49 More Refineries on the Rhine *by A. M. Stahmer*

54 Development and Prospects for Petrochemistry *by Dr. Alfons Metzner*

62 Production of Olefins in the Lurgi Ruhrgas Sand Cracker

65 German Engineering Contributions to the Processing of Crude Oil edited *by Dipl. Ing. Karl Palzer*

258 Transportation of Mineral Oil *by Dr. Ing. Hans Christoph Seebohm*

261 Hamburg, Germany's Oil Port

264 Economics of Pipeline Planning *by Friedrich Zimmermann*

266 Oil Flows, Swims and Rolls *by Gerhard Geyer*

268 Tanker Construction

272 Wilhelmshaven—Europort No. 2? *by Arthur Gruenwald*

Holland

Editors: *Dr. H. A. Stheeman and Dr. H. ter Meulen*
Introduction *by C. J. Andriessen*

1 The energy position in the Netherlands and the place of oil in it. *by Dr. P. Schierbeek*

4 Oil and gas production in the Netherlands
A. Geology and exploration results
B. Geophysical exploration
C. Mining Act and Concessions
D. Drilling and development

13 Petroleum gas and the State Gas Service *by Ch. A. Hoffman*

14 Manufacturing

17 Dutch tanker fleet continues to grow

18 Holland's first trunkline

19 Research

21 The Netherlands as a market for petroleum products

25 Drilling contractors incorporated in the Netherlands

27 The Royal Dutch Salt Industry

Italy

3 Development of the Italian Petroleum Industry *by Enrico Mattei*

14 Refining and Distribution of Petroleum Products in Italy *by Dr. Vincenzo Cazzaniga*

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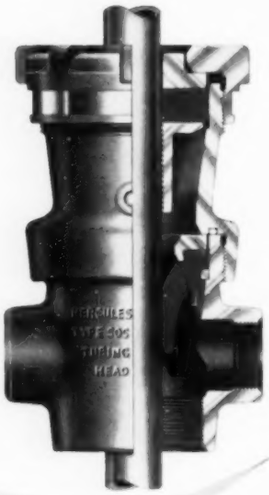

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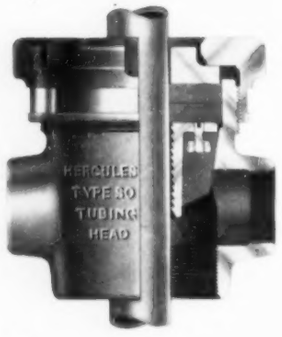

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Washington

By Joseph B. Huttlinger

The virtual exemption of Canadian crude oil from the mandatory oil imports program is likely to have more political than economic meaning, according to officials in Washington. It represents the first sign that Washington is open to major changes in the imports program; so it is expected to touch off new pressure for changes. Thus, the next logical question is what can be worked out for our Latin American friends?

In terms of barrels daily of crude-oil imports, the change may mean little, or it may be substantial. An informed USA official said the action is likely to add only about 10,000 b/d of crude imports from Canada to the USA. Imports have been about 85,000 b/d in the past year, and in recent months. Others recall that crude imports from Canada to the USA rose to about 150,000 b/d during 1957, and say they may approach this level in the near future. Some 19,000 b d of these were by tanker, however, a type of shipment which is not covered by the exemption: the latter applies only to crude arriving by rail, truck, or pipeline. These persons add that the exemption of Canadian pipeline crude to the USA from the import curbs may encourage some persons to build new oil refineries in the USA Pacific Northwest, which could make an added market in the future.

Despite these factors indicating a marked rise in imports from Canada, it is freely admitted that the 1957 imports were swelled by the unusual demands stemming from the Suez Canal shutdown. And, it is said, conditions have changed in the past two years, so that prices of Middle East and Venezuelan crudes have been cut, and thus these crudes are more attractive than Canadian or USA.

Exemption of Mexican crude imports is expected to pave the way for more exchanges between the USA and her southern neighbor. Mexico has been a net importer of crude. Last year, her imports were 13,308,000 bbl compared with exports of 12,444,060 bbl. In 1957, the figures were 18,407,333 bbl of imports against 17,149,036 bbl of exports.

To Test Legality

An early test in the courts of the new mandatory oil-imports program appears certain. Several oil companies filed appeals with the oil-import appeals board apparently in the expectation they will be turned down. Then, the way is clear for them to challenge the program in the courts. Several large oil-importing companies have used strong language about the pro-

Pipeline

gram in their filings with the appeals board. Words such as "arbitrary and unjust," "unfair and discriminatory," and an "unreasonable hardship," are among those used by such companies as Standard Oil Co. (N.J.), The Texas Co., and others. Tidewater Oil Corp. called it "unlawful confiscation." The appeals, which number close to 70, ask many types of relief—all of them adding up to requests for more import quotas.

Jersey Standard and its affiliates, including Humble, Esso, and Carter, object to the "sliding scale" under which the smaller refineries get a larger percentage of their crude runs in the form of imports. The Jersey family also objects to counting up all subsidiaries to get one total figure of refinery runs, preferring a quota for each subsidiary. Jersey also objects to including residual in the program.

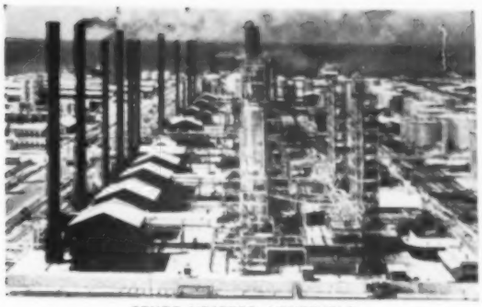
Gulf asks its residual quota be raised from 2,019 b/d to 35,000 b/d, to base it on marketing plans of the company.

And Senator Thomas Kuchel (R., Calif.) has written Secretary of the Interior Fred A. Seaton on behalf of California importers who want an end to the limit of 10% unfinished oils in their quotas for crude and unfinished oils.

The appeals board, probably, will duck broad requests such as these, on the grounds it lacks the authority to handle them. Once the board turns down an appeal, or acts on it, the way is clear for going into court.

The appeals board faces, however, other questions, including these: (1) can it give a quota to a company with a history of importing crude, but which lacks a refinery? This is the issue in the case of E. A. Gabriel, head of the Gabriel Oil Co., Houston; (2) can the appeals board allow credit for exports by granting larger quotas? Eastern States Petroleum and Chemical Corp., Union Oil Co. of California, and Richfield Oil Corp. have asked such action; (3) can the board give credit for periods when a refinery was shut down by fire or strike or other cause? (4) can the board give quotas to import special products? Requests in this field ask quotas to import propane gas, comingled crude, asphalt and petroleum bitumen, residual for bunkering ships, crude reconstituted by addition of naptha, LPGas, and special lube oils.

The appeals board, itself, appears determined to hold the line, as indicated in its decision denying any relief to Whale Oil Co., which ordered two cargoes of residual from the Middle East last January, and received it during April after the program had begun.



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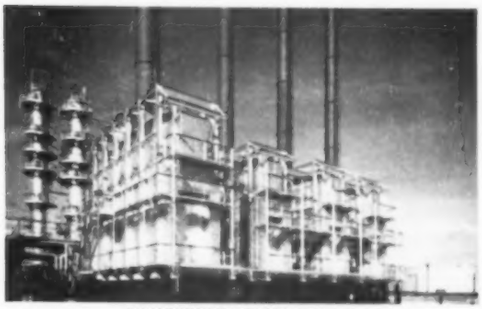

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What happened at Cairo

by Jean Jacques Berreby

THE Arab Oil Congress surprised everyone. Instead of a political forum resounding with charges and countercharges, it was a scientific and technical meeting, with submission of papers and sessions along traditional lines. It could perhaps be summed up in saying "All's well that ends well." To one Egyptian delegate, however, it was "a deception." To most oil-industry representatives, it was a relief.

The final published resolution of the congress brought out points which were not discussed. It summarized many of the principal claims of producing countries today, and is here reproduced in full.

Final Resolution—The First Petroleum Arab Congress

"The delegates to the congress have found themselves in general understanding on such matters as the improvement of the participation of the petroleum producing countries, on an equitable and reasonable basis, the desirability to reach integration of the petroleum industry, the establishment of national petroleum companies which would operate side by side with the existing private companies, and the need for setting up special machinery to coordinate, at the national level, the conservatoin, production and export of petroleum into due account in all these matters the conditions prevailing in each country.

"The delegates have found it desirable that the government with petroleum resources should from time to time exchange views and experiences on common problems concerning conservation, production and export of petroleum as well as other related matters, in order to help in the coordination and harmonization of their respective approaches and actions, and to contribute to the steady and regular flow of petroleum into the international markets.

"They also believe that changes in the system of pricing, or any change in the price of crude oil and its products, should not take place prior to declaration, by producing companies, of such prices; and discussion and study with the governments of the exporting countries concerned.

"They also recognize that it is advisable for governments of countries with petroleum resources to consider the possibility of taking steps towards the establishment of a system of consultations as a means to exchange views and experiences on common problems concerning the conservation, production, and export of petroleum as well as other related matters.

"The Delegates also seize the opportunity to outline the importance they attach to the execution of the Arab Pipelines Project, the necessity of increasing refining capacity in the oil producing countries, the setting up of petrochemical industries as well as institutes and centres, necessary for the formation of national technicians, and their training to do all jobs and carry out the different operations connected with the petroleum activities.

"The Delegates also recognize the advisability to refer the project submitted to the Congress by the Lebanese Delegation to the competent Authorities in the League of Arab States.

"The Delegates also recommend the holding of this Congress yearly."

Aside from the technical papers, which are listed (along with their non-technical counterparts) in this article, four proposals were of major interest:

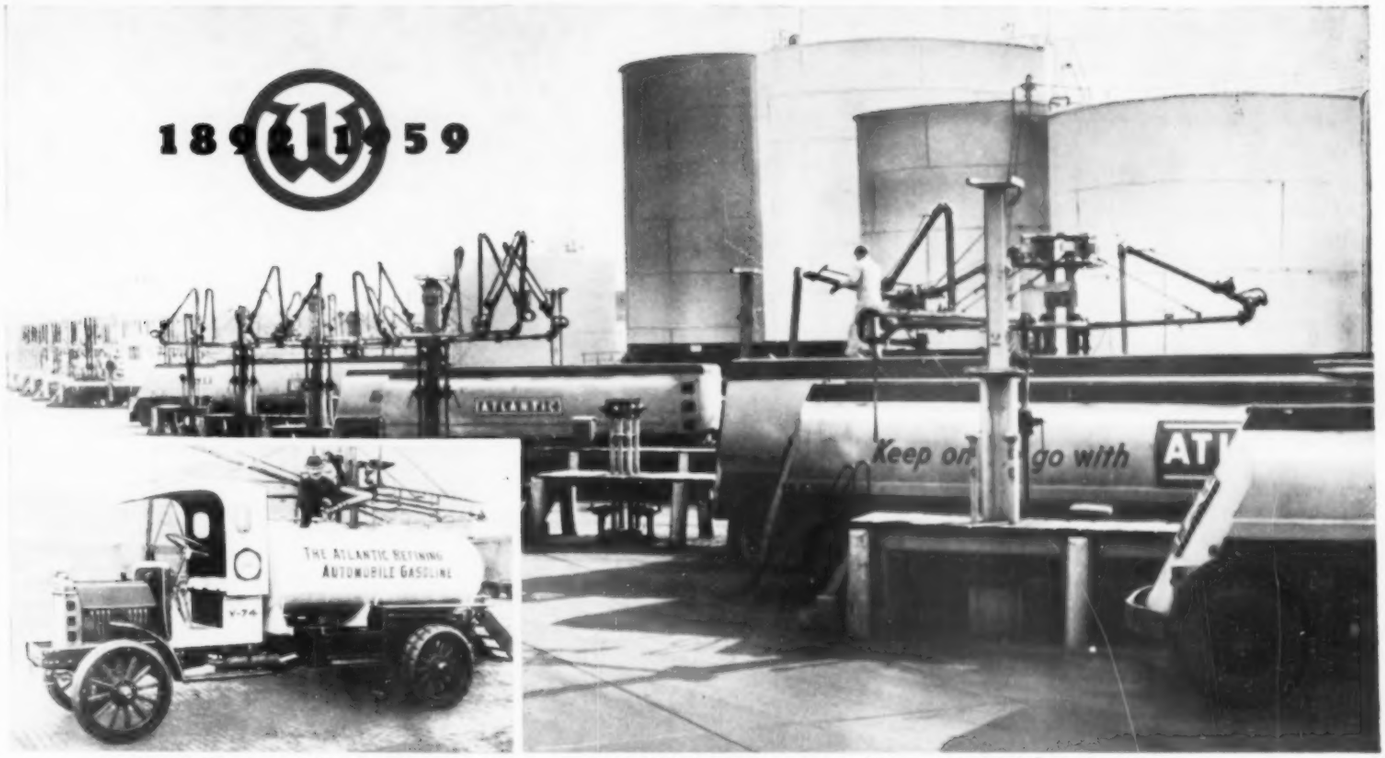
Arab-Owned Pipeline: First was for the Arab-owned pipeline from the Persian Gulf to the Mediterranean. The companies seem to support this scheme, perhaps because they feel it would decrease the line's vulnerability in time of unrest. The original idea is old, and has long had the approval of the Arab States. A paper submitted by the delegate of Saudi Arabia, entitled "Middle East Pipe-Lines and Their Economic Future," stated, in summary, that, due to shorter transportation haul, Arab oil was the natural supplier for Middle East marmets. It further points out that the percentage of Middle East crude transported by pipelines is steadily decreasing—from about 22% in 1956 to 19% in 1958. The paper estimated Middle East production of crude oil at 11.5 million barrels daily in 1967, and at about 16.8 million barrels in 1975. The additional amount of this production which would be available for pipeline transport was estimated 1,250,000 b/d. The paper then discusses the economics of a 40-in. line of about 1,250 miles in length. Capacity would be about 800,000 b/d, and the cost is estimated at 40% over Tapline's cost, which was about $161,682 per mile in 1951. The financing would be based on loans from commercial banks in consuming countries. In later conversations, Arab delegates indicated that net profits on the operation would be in the neighborhood of $100 million yearly; and they stated that, since royalties received from existing pipeline companies now for the same throughput do not exceed $58 million yearly, a gain of some $30 million yearly would accrue to the Arab States.

Considerable stir resulted from a paper read by Frank Hendryx, legal advisor to the Directorate General of Petroleum and Mineral Affairs in Saudi Arabia. In a paper entitled "A Sovereign Nation's Legal Ability to Make and Abide by a Petroleum Concession Contract," he stated that "the purpose for which governments exists, the service of their peoples, requires that on proper occasion those governments must be released from or be able to override their contractual obligations." His assertion carried weight, since it was assumed he was speaking for the Saudi Arabs. General reaction was immediately hostile to such a sweeping declaration, however, and the Saudi Arabian delegation hastened to explain that they had no intention of abrogating their own concession contracts on that basis. An official of the UAR's General Petroleum Authority then pointed out that contracts normally include clauses for arbitration of disputes. A statement by Anis Qasem, Petroleum Commissioner for Libya, was greeted with more enthusiasm when he stated that Libya had no intention of abrogating any of her contracts without mutual consent.

Emile Bustani, of Lebanon, proposed that 5% of the yearly gross profits from oil operations be deduced before any taxes, royalties, etc., were taken out. The sums form the capital of an Arab Development Bank which would finance development and industrial projects in the Arab world, though a National Development Company in each Arab State, would be owned 50% by the government and 50% by private citizens. These would finance development schemes at nominal interest rates, not exceeding 2½%. To provide incentives for companies, the donations from oil capital (which would be supplied from gross and, therefore, equally by company and country) would be matched by guarantees via treaty-guaranteeing pipelines crossing their territories.

A memorandum was submitted to the congress by the delegates from Saudi Arabia in 22 pages. It covered the general marketing considerations for the Middle East, including such things as production, prices, market growth, etc.

The Venezuelan delegation to the congress consisted of about 12 members, headed by the Minister of Mines, Juan Pablo Perez Alfonso, the former minister during President Betancourt's previous administration in 1948. He proposed to the Arab States a sort of international conservation scheme, whereby the principal exporting nations of the Middle East and Venezuela would combine to limit production and thereby strengthen prices. This would involve, he said, a division of future markets along the same percentage lines



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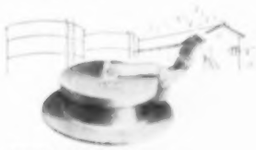

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as at present; for example, if Venezuela had 40% of the market in a given area, she would continue to maintain that percentage and the Arab nations would likewise retain their percentage position in all future increases in that market. Whatever the results of his discussions may be, they will not be immediate. It was the opinion of Sheikh Abdullah Tariki, Director of Petroleum and Mineral Affairs for Saudi Arabia, however, that much is to be gained in cooperation with Venezuela. "As a matter of fact, I think close contacts with Venezuela will assist us," he told WORLD PETROLEUM's correspondent; "they can be an example and a leader for us." He further stated "We are after security, not only profits; we shall either lose or gain on all activities, but we want a share in all of them; we want to build a market of our own, to get Aramco out of the grasp of parent companies for the benefit of the Saudi people and of the shareholder, whoever he may be; we want Aramco to be a Saudi company in the same way that Shell is an American company when it operates in the United States, that's clear enough. . . . An example of integration is already working with the Japanese, and a contract was concluded with Pan American but the board rejected it in New York. What you have to say is this: We shall never conclude any more agreements below the terms of the Japanese contract; anybody seeking a concession below those terms should not even lose time in coming to see us."

PRINCIPAL papers submitted to the Pan Arab Petroleum Congress are listed by country as follows:

UNITED ARAB REPUBLIC (EGYPT AND SYRIA): *The Arab League, The First Arab Oil Conference on The Legal, Economic, and Political Effects Resulting from The Principle of the State Ownership of the Mineral Wealth in Its Territory*, by Farouk Muhamed El-Bakkary; *Stability of Petroleum Products and Methods Used for Assessing It*, by Galil Ibrahim El Soussou, Chief Chemist; *Discussion on Resistivity and Radio Activity Logs of Representative Wells Drilled in a Field of the Egyptian Province of the United Arab Republic*, by G. P. Adamson and O. De Coulon; *Petroleum Institute*, General Petroleum Authority. Some notes on *Migrated Time-Sections, As Used For Representation of Seismic Data, Egyptian Deserts*, by Raafat Badrawy, Geophysicist, Ste. Cooperative des Pétroles; *Significance of Unique Interpretation of Geophysical Data in Ras Gharib*, by Dr. M. Kamiel, Prof. of Geophysics, Alexandria University; *A.E.O. Refinery Suez, Engineering Dept., Study of 12" Suez-Cairo Black Oil Pipeline*, by Sami Andrawis and Abdel Razzak Rashad; *Water Supply in the Oil Fields of the Egyptian Region*, by Eng. Nazmi Youssef, Anglo Egyptian Oilfields Ltd. (under custodianship); *Facies Maps for the Study of the Palaezoic and Mesozoic Sedimentary Basins of the Egyptian Region, UAR*, by A. Bandali Kostanki, The Anglo-Egyptian Oilfields Ltd. (under sequestration); *Petroleum & Farm Mechanization*, by Saad Hassan Ismail; *Programmes: Their Effect on the Efficiency of Refineries*, by Selim Kerollos, Chemical Engineer; *Bunker Oil*, by Engineer Ezz-El-Deen Refaat; *Petroleum Fuels in the Building Materials Industry*, by Engineer G. S. Bishai, Technical Dept., The Shell Co. of Egypt Ltd.; *Insecticides from Petroleum Origin*, by Tag El Dine Amer, Chemist, Ste. Cooperative des Pétroles; *Chemical Desalting of Balaim Crudes*, by A. Nour El Deen, Assistant Chief Chemist AEO Suez Laboratory; *Bitumen for Lining Irrigation Canals*, by Engineers Yousef Akhnoukh and Ragi Tewfik, The Shell Co. of Egypt Ltd. (under custodianship); *Bituminous Soil Stabilization for Road Foundations*, by Engineer Yousef Akhnoukh, The Shell Co. of Egypt Ltd. (under custodianship); *The Development of Ras Gharib Dehydration Plant*, by Mustafa K. Salem; *Corrosion Experienced in the Benzine Condensers of the Crude Distillation Plant at AEO Suez Refinery*, by A. E. Hilal and L. B. Faltas; *Medium Pressure Catalytic Hydrocracking of Balaeim Crude*, by Dr. Amin El Eraby; *Application of Heat in Secondary Recovery of Oil*, by Dr. Taher A. Hadidi; *Electronic Instrumentation of Industrial Processes*, author unknown; *Gas Phase Chromatography*, by Dr. Fathy Mossad Ebeid, Research-Worker, Petroleum Chemistry Unit, National Research Center, Cairo; *Corrosion & Cathodic Protection in Ras Gharib Field*, by B. A. Malek; *Significance of Unique Interpretation of Geophysical Data in Ras Gharib*, by Dr. M. Kamiel, Prof. of Geophysics, Alexandria University; *The Western Desert Through the Ages*, by Dr. Fayek Faltas, Fuel Dept. (UAR); *Progress and Evolution of Drilling Operations*, by A. Fayed, Production Manager, Ste. Cooperative des Pétroles; *Dual Completion and Its Application in Egypt*, by Morad Bishlawi; *Petroleum Geology*, by Prof. Dr. Mohamed I. Faris, Head of Dept. of Geology, Ain Shams University; *Migrated Time-Sections, As Used for Representation of Seismic Data, Egyptian Deserts*, by Raafat Badrawy, Geophysicist, Ste. Cooperative des Pétroles; *Exploration Efforts and Their Bearing on The Oil Prospects of the United Arab Republic, Part II, The Syrian Region*, by M. A. Ghorab and M. S. Amin, Exploration & Production Dept., The Petroleum General Authority, Cairo—UAR.

SAUDI ARABIA: Second in number of papers was the Saudi Arabian delegation. Among the papers submitted by the delegation were three by the Aramco (Arabian American Oil Co.), principal concessionaire company in Saudi Arabia. They were: *Seismic Exploration in Saudi Arabia*, author unknown; *Gas Turbine Pumping Units of the Trans-Arabian Pipe Line*, by R. R. Burnett, assistant chief engineer of Tapline, based on the paper by W. E. Locher, A. E. Olson, and P. P. Nibley, presented at the API Annual Pipeline Conference in New Orleans, March 31 to April 2, 1958; *Ghawar Oil Field, Saudi Arabia* (based on the paper of the same title as published in the *Bulletin of the American Association of Petroleum Geologists* for February 1959).

Among the other papers submitted by the persons attending from Saudi Arabia were: *An Outline of Petroleum Conservation and Its Application in the Middle East*, by M. J. Sladic, Senior Reservoir Engineer, Directorate General of Petroleum & Mineral Affairs, Saudi Arabia; *Oil-Industry Technical Terms in Arabic*, prepared by Peter C. Speers, Arabian American Oil Co., Dhahran, Saudi Arabia; *Gravity Measurements in Saudi Arabia*, by Abdel Karim Ghalayini, Directorate General of Pet. & Mineral Affairs, Ministry of Finance & National Economy; *Structure Drilling in Saudi Arabia*, by Allan H. Shurrab, Directorate General of Pet. & Mineral Affairs, Ministry of Finance & National Economy; *A Sovereign Nation's Legal Ability to Make and Abide by a Petroleum Concession Contract*, by F. Hendryx, Directorate General of Petroleum and Mineral Affairs. Ministry of Finance & National Economy; *Middle East Pipe Lines and Their Economic Future*, by the Delegate of Saudi Arabia to the Committee of Oil Experts in the Arab League.

KUWAIT: Three papers were submitted by the Kuwait Oil Co., including the following: *Modern Crude Oil Loading Techniques at Mina-al-Ahmadi, Kuwait*, by J. M. Dougary; *Some Corrosion Problems Encountered in the Development of Oil Resources*, by G. A. Lee; and *Variations with Elevation of Kuwait Reservoir Fluids*, by George Hetherington and Dr. A. J. Horan.

LIBYA: Two papers were submitted by the Libyan delegation. They were: *Petroleum Legislation in Libya*, by Anis Qasem, Member and Adviser, Libyan Petroleum Commission, Petroleum Adviser to the Ministry of National Economy; and *Development of Petroleum Exploration in Libya*, by A. Hogenhuis, Director of Petroleum Affairs, Libyan Petroleum Commission.

LEBANON: Two papers on Trans-Arabian Pipe Line Co. operations were submitted by the members of the company which were present. They were: *Gas Turbine Pumping Units on the Trans-Arabian Pipeline*, by R. R. Burnett; and *Control of External Corrosion on the Trans-Arabian Pipe Line*, by F. M. Maasry. A paper was submitted by Emile Bustani, M.P., entitled *Sharing Oil Benefits*.

QATAR: A paper on the deepest wildcat to date in Qatar, the Dukhan well, was submitted by R. Milne, of the Qatar Petroleum Co. Ltd. Title is *The Dukhan Deep Test*.

OTHER: Some papers were given on general subjects; titles were as follows: *Marine Seismic Prospecting*, by Dr. Hans von Helms, vice president of PRAKLA GmbH, Hanover, Germany; *Economics of Petroleum in The Middle East*, author unknown; *The Role of The League of Arab States in Petroleum Affairs*, by The Petroleum Department of The League of Arab States. END

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FRANCE

LONDON LETTER

By Cecil W. Wood

UK Consumption Rises

At 31,065,629 long tons, UK deliveries into consumption in 1958 (excluding bunkers for ships engaged in foreign trade) show a rise of 6,281,061 tons (25.3%) over 1957, and of 5,842,580 (23.2%) over 1956. Comparison with the 1957 total of 24,784,568 tons is unrealistic owing to the restrictions on consumption following the Suez Canal closure. It is more realistic to regard the average annual rise over the past three years as 2,576,162 long tons, or 10.7%. A summary of the detailed statistics, collated independently on behalf of the UK Petroleum Industry Advisory Committee, and issued by Petroleum Information Bureau, is shown in Table I.

TABLE I
UK Deliveries into Consumption
(Millions of Long Tons)

	1958	*1957*	*1956*
Aviation fuel	1.6	1.6	1.7
Motor spirit	6.6	5.8	6.3
Industrial and white spirits	0.3	0.3	0.3
Kerosine	1.6	1.3	1.4
Diesel-engine fuel	2.0	1.8	1.8
Gas-diesel oils	3.0	2.3	2.4
Fuel oil*	13.1	9.1	8.6
Lubricating oil	0.9	0.8	0.9
Bitumen	0.9	0.9	1.0
Other products	1.1	0.9	0.8
Total	31.1	24.8	25.2
Increase over preceding year—			
Quantity	+ 6.3	—0.4	+2.0
Per cent	+25.3	—1.7	+8.5

* Includes refinery consumption: 1958, 2.5; 1957, 2.1; 1956, 2.2.

It is the great and continued rise in fuel-oil consumption which is the outstanding feature. The rise is spread over all fields, as can be illustrated by the following 1958 totals (in millions of tons; 1957 figures on brackets): burning, 10.4 (6.6); power, 2.3 (2.0); manufacturing, 0.7 (0.5); and refinery and petroleum-industry use 2.7 (2.3). The most striking individual end-use change was for steam raising in public electricity generation, 2.6 (up not less than 2.0 on 1957); other appreciable rises were steam raising, 2.7 (up 0.8); central heating, 1.9 (up 0.6); and gas making, 0.7 (up 0.2).

Deliveries of motor spirit (including motor benzol) are put at 3,636,000 tons (31,789,000 bbl) in 1958, against 3,040,000 tons (26,839,000 bbl) in 1957, and 3,140,000 tons (27,722,000 bbl) in 1956.

Shell Intl. Chemical Co.

A new organizational pattern for the London and The Hague offices of The Shell Petroleum Co. Ltd. and NV de Bataafsche Petroleum Mij. has been drawn up following a lengthy investigation by independent management consultants. In particular, this new pattern takes into account the growing importance of the group's chemical activities and its basic difference from, but necessarily close relationship to, the petroleum side. As a result, the following four new companies have been formed to take over certain supply activities and responsibility for advice and services to the many operating companies which make up the group: *For oil*—London, Shell International Petroleum Co. Ltd.; The Hague, Bataafse International Petroleum Mij. NV. *For chemicals*—London, Shell International Chemical Co. Ltd.; The Hague, Bataafse International Chemie Mij. NV.

It should be noted that the new spelling of "Bataafse" is used. Shell Petroleum and BPM will henceforth function mainly in a shareholding capacity. It is also stated that the seven individuals generally known as "managing directors of the Royal Dutch Shell group" will be directors of these new companies and, as such, will constitute a joint committee called the "managing directors' committee." Day-to-day coordination of the oil and chemical businesses (excluding North America) will be in the hands of two directors of coordination, J. P. Berkin for oil and W. F. Mitchell for chemicals.

British Equipment Notes

Two British-made rigs capable of drilling to 12,000 ft have been dispatched to Iraq for use by *Keir & Cawder Arrow Drilling (UK) Ltd.* on behalf of Basrah Petroleum in the Rumaila oil field in southern Iraq. The first of the new wells is expected to be spudded in about mid-August. For movements between locations, the complete rigs will be mounted on tracks drawn by Caterpillar tractors—the first to come off the assembly line of the new Caterpillar factory at Tannochside, near Glasgow.

Computer-controlled file-cutting machines developed by *British Oxygen Gases Ltd.* in conjunction with Ferranti have been introduced into the yards of Swan Hunter & Wigham Richardson and of Vickers-Armstrongs. (Shipbuilders). This is regarded as a major step towards the introduction of automation in cutting steel plate rapidly and accurately for shipbuilding.

Some of the latest equipment and techniques developed by British Oxygen Gases were shown to oil-company representatives in London recently. It was the first such organized visit, and was impressive for the wide range of demonstrations of both manual and automatic equipment, including the flame-cutting of a 60-in. steel slab and of concrete. Among the new items seen were the 'Alyn' tube profile cutting machine for branch work, both on site and in workshop, without the need of marking off; the CIG pipe-cutting machine; and the latest developments in Argonarc welding. The company is now concentrating on improving its overseas services; and A.R.A. Hall, export sales manager, has recently made a two months; Middle East tour of oil centers with this object. In fact, one of the reasons for gathering of oil men was to learn from them more about their companies' problems and in what directions British Oxygen could best provide a higher degree of service overseas.

Stewarts & Lloyds Ltd. recently negotiated two contracts with Russia, covering the largest order it has received from this source since before World War II. One is for £460,000 worth of boiler and steam tubes (5,500 tons), and the other for £383,000 worth of oil-well tubing (4,100 tons). Shipment of the boiler and steam tubes started in May, and the tubing was to start in four to six weeks from the signing of the contract and to continue at the rate of about 300 tons a week.

Fisher Governor Co. Ltd. has recently shown its full-color instructional film "Muscles of Control" to a large gathering of oil men in London. This deals lucidly with many types of automatic valve actuators, from the pneumatic-spring diagraphm valve to the very latest electrohydraulic device, and explains the many technical difficulties met in selecting the right valve for the right job. Other aspects portrayed clearly are the advantages and disadvantages of single-port and double-port types and the problems posed by the demand for differing types of inner valves. Copies may be loaned free from the company at Airport Works, Rochester, Kent.

Progress At Milford Haven

End-March saw the last of the 157 steel piles being driven in the 1,300-ft jetty which British Petroleum Co. is building as part of its £6.5 million new tanker terminal at Abgle Bay on the south shore of Milford Haven. Work only started on this project at the end of 1957, and thus progress has been rapid, especially as another 92 piles have been driven to carry the sea arm which will stretch for 2,500 ft at right angles to the shore arm and be capable of accommodating simultaneously two of the biggest tankers envisaged at present. Work is also proceeding actively on the 60-mile 18-in. pipeline to connect this terminal with the Llandarcy refinery.

Oil Find In Dorset

An encouraging oil show in limestones at about 1,800 ft has been met by BP Exploration Co. in Broadbench well No. 1, near Kimmeridge in Dorset. Drilling is continuing, probably to 4,000 ft, and much work will be required before it is known whether the find is likely to prove commercial.

New Tranmere Terminal

Good progress is reported on the work commenced last summer by the Mersey docks and harbor board on the construction of the floating stages at Tranmere for the discharge of supertankers to feed Shell's Stanlow refinery. Each of these floating stages will be 366 ft long and 60 ft wide, with a timber deck supported on steel work. By March, the structural elements of the single shore arm of the approach jetty across the foreshore had been substantially completed, and work was in progress on the north and south branches. Seven "Mannesmann" tubes and one concrete cylinder had been placed in their prepared holes by the board's 200-ton floating crane.

New Appointments

A. L. BROWN has been appointed a director of Shell Trinidad Ltd., to succeed M. W. Godfrey.

F. B. PORGES, managing director of Flexibox Ltd., has been appointed a director of Manchester Oil Refinery (Holdings) Ltd.

J. S. BROUGH, general manager of production for Monsanto Chemicals Ltd., has joined Humphreys & Glasgow Ltd. as technical director and general manager. He will act as deputy to G. G. Farthing, deputy chairman and managing director. Mr. Brough is a fellow of the Institute of Petroleum, and has been with Monsanto since shortly after the war.

Dr. T. HOWARD BUTLER, chairman since 1935 of William Butler & Co. (Bristol) Ltd., oil refiners, has retired from the board, and is succeeded by his brother, Eric W. Butler, formerly vice chairman. E. PETER BUTLER and T. CYRIL BUTLER, formerly joint managing directors, became vice chairman and sole managing director, respectively.

MICHAEL J. GALPIN, who joined Clark Bros. Co. as manager of the London office over 10 years ago, has been appointed to the new post of director of European operations, and will maintain his headquarters in London. Before joining Clark Bros., Mr. Galpin had spent some 20 years with the British Petroleum group and had wide experience of oil operations in various positions in Iran, Iraq, and Romania. JACK BROWN, assistant manager of the London office since January 1957, has been appointed manager. Mr. Brown joined the company in 1950 from Alley & McLellan and, after two years in the Olean office, returned to London as Clark sales engineer.

F. A. C. GUEPIN, managing director of Royal Dutch since 1950, retired as of June 30, but will be offered a seat on the board. A. HOFLAND, OBE, who since 1955 has been a director of Shell Petroleum in London with special responsibility for marketing products, has been nominated to succeed Mr. Guepin as managing director. Following his appointment, it is intended to make him a principal director of Bataafse Petroleum and a managing director of Shell Petroleum.

LORD ROTHSCHILD, FRS, has joined the board of "Shell" Research Ltd. as part-time adviser on research. A distinguished scientist in several directions, he has since the war been mostly associated with agricultural and biophysical research, and is assistant director of the department of zoology at Cambridge University. Until recently, he was chairman of the agricultural research council for a period of 10 years. Most of his war work is still secret, but enough is known to denote it as of a very courageous nature. This was recognized in Britain by the award of the George Medal for "dangerous work in hazardous circumstances," and in the USA—where he spent some time on military intelligence—by the award of the Bronze Medal and Legion of Merit.

More USA Equipment Links

Ruston & Hornsby Ltd., Lincoln, has secured a manufacturing license for the patented high-pressure and temperature connections of Gray Tool Co., of Houston. These employ a unique sealing system, and will be made at Lincoln under the name "Ruston-Grayloc." They will be the first of their type available outside the USA.

The affiliation of two century-old power-transmission equipment manufacturers has been announced. The David Brown Corp. Ltd., one of the principal British engineering combines and the largest manufacturer of gearing in Europe and the commonwealth, has acquired a substantial minority share interest in Foote Bros. Gear & Machine Corp., of Chicago, and will have two members on its board. The latter is widely known in the power-transmission field, and is celebrating its 100th anniversary this year.

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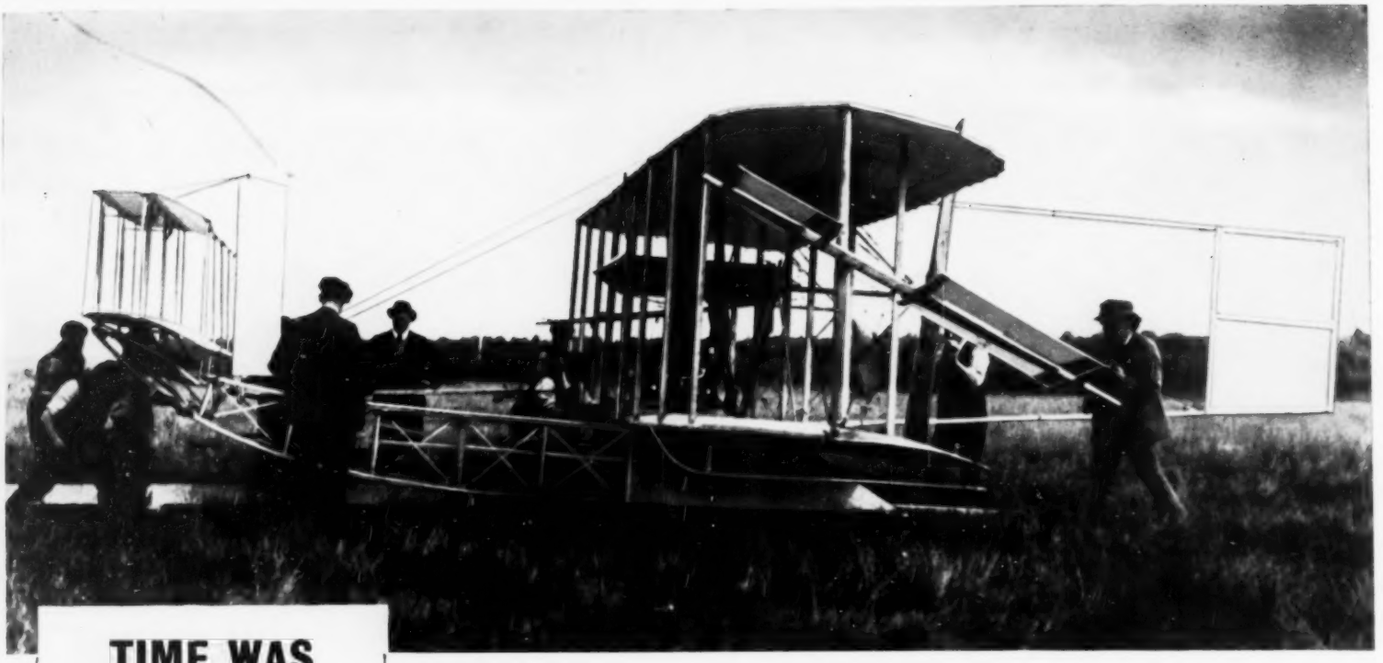

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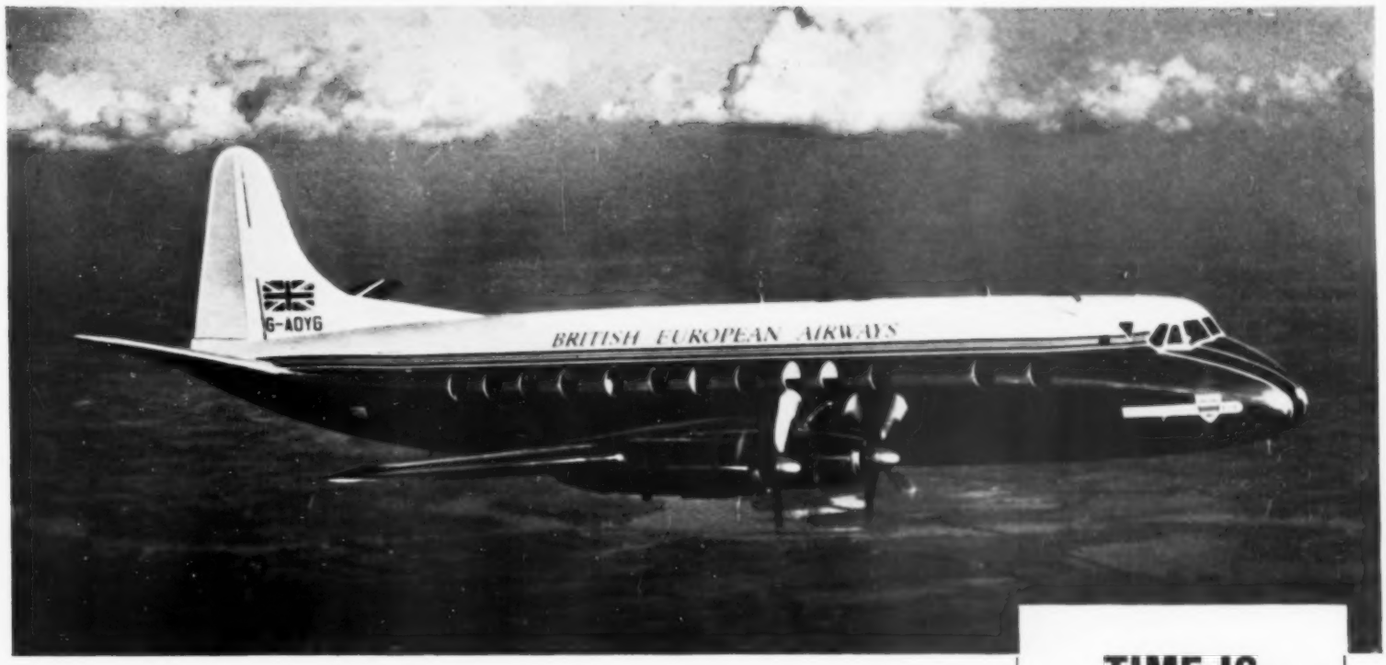
50 UP

THE BRITISH



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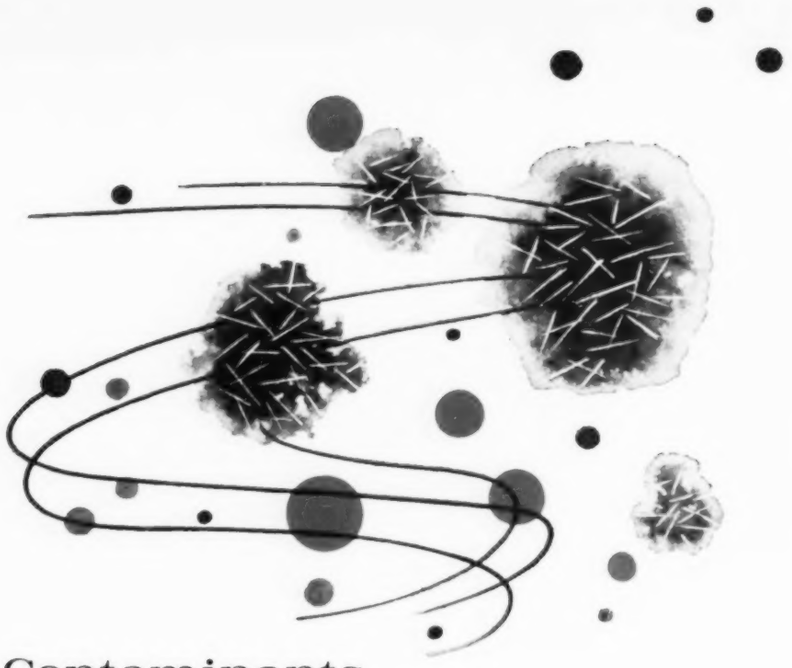

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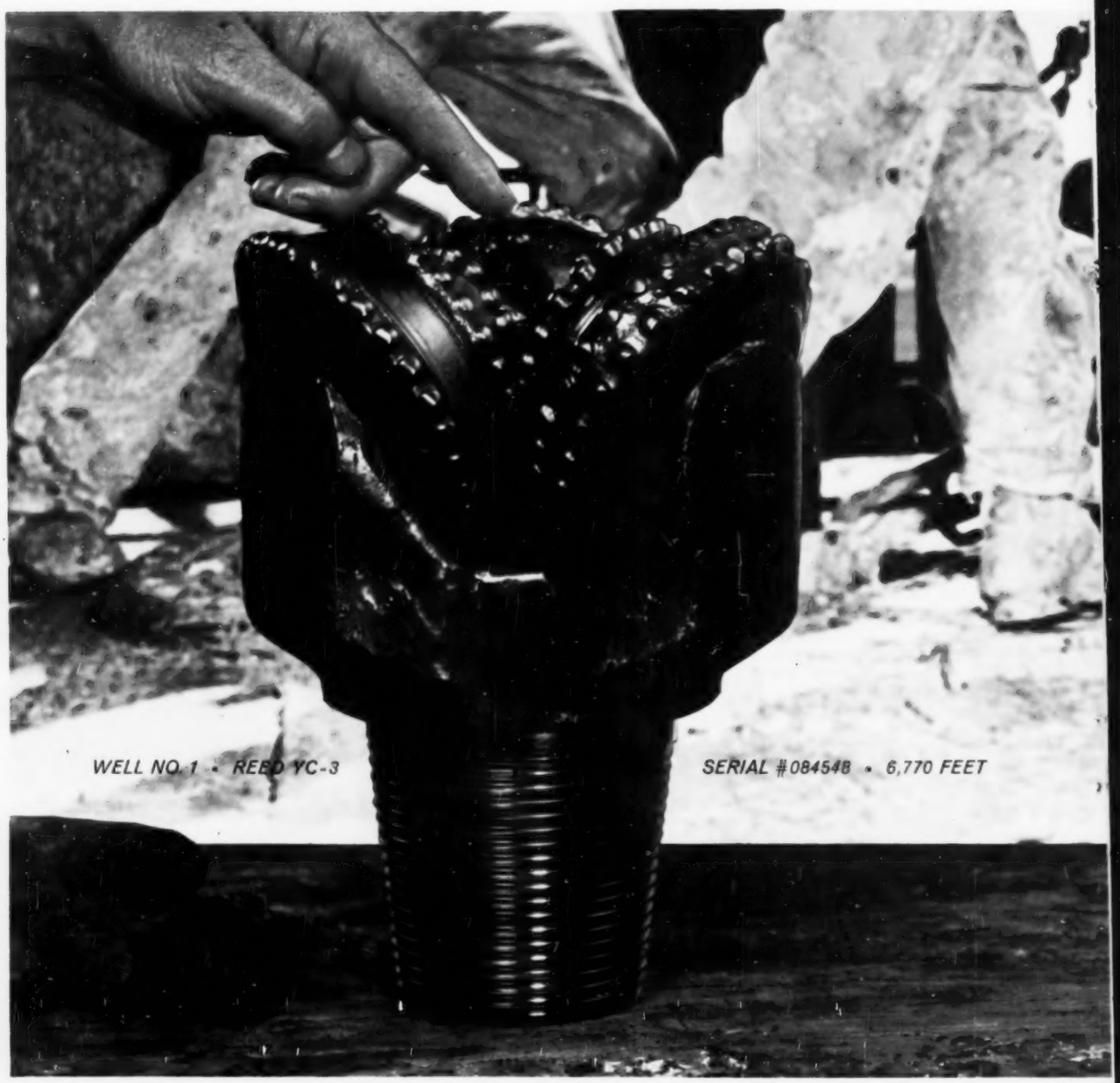

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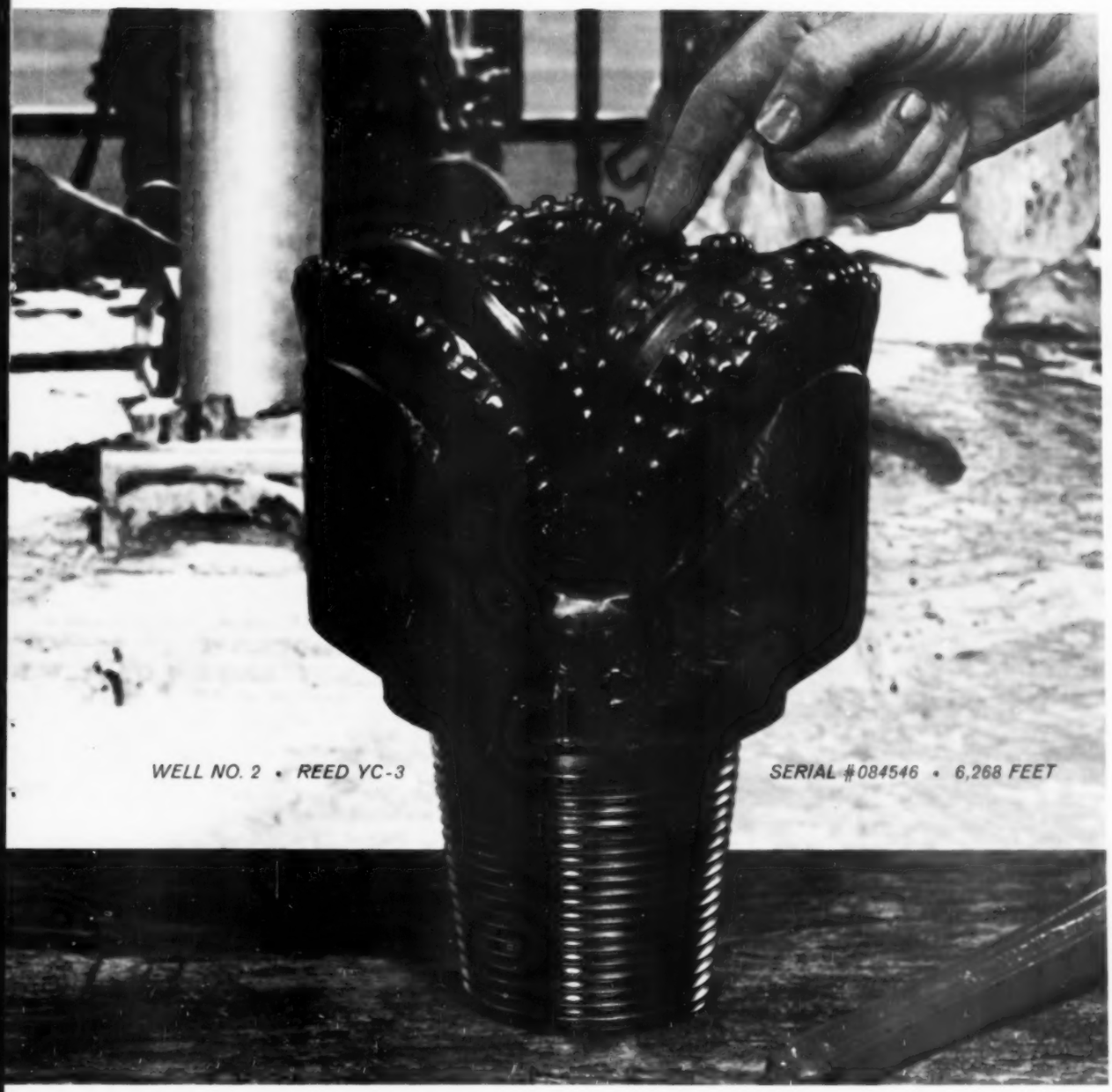

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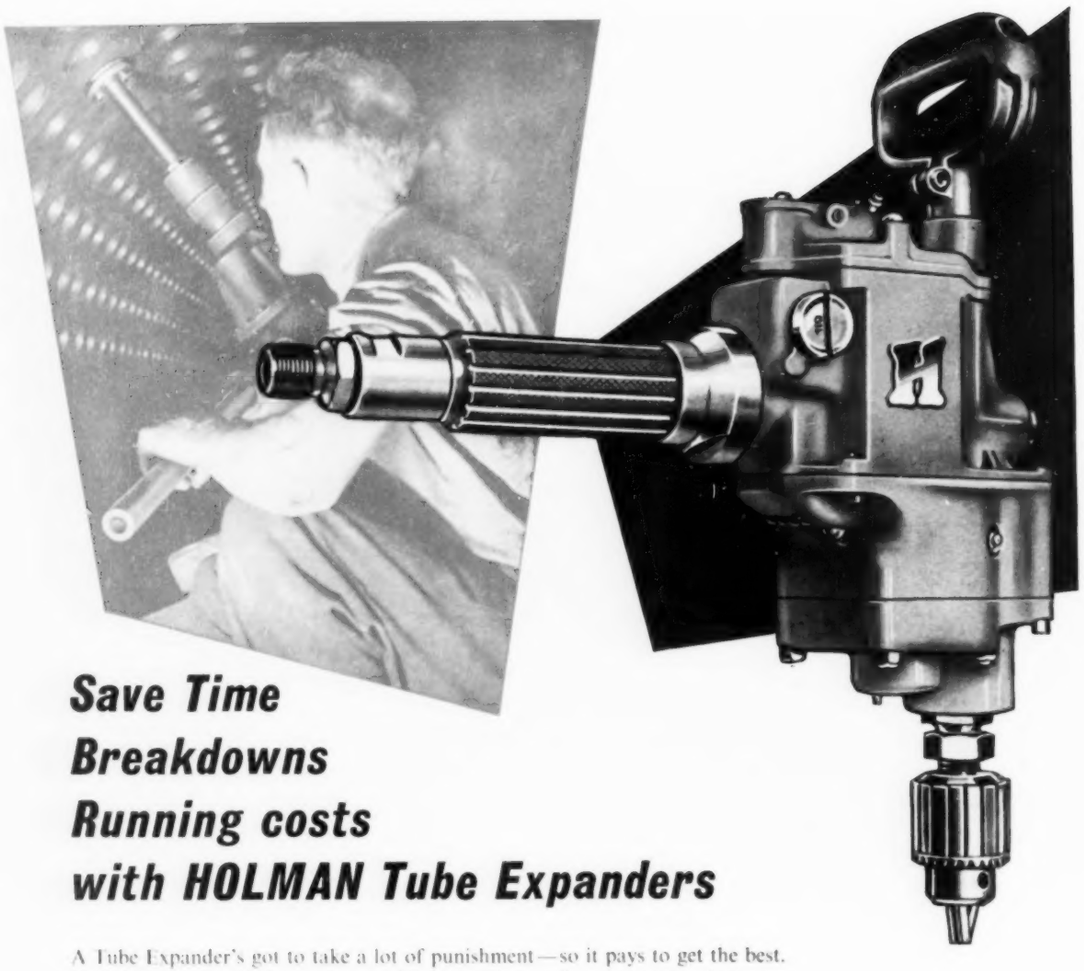

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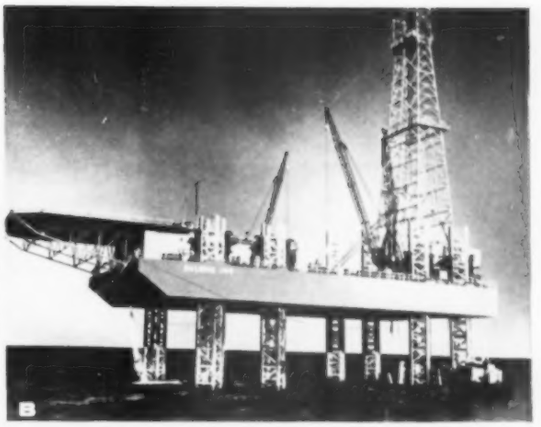

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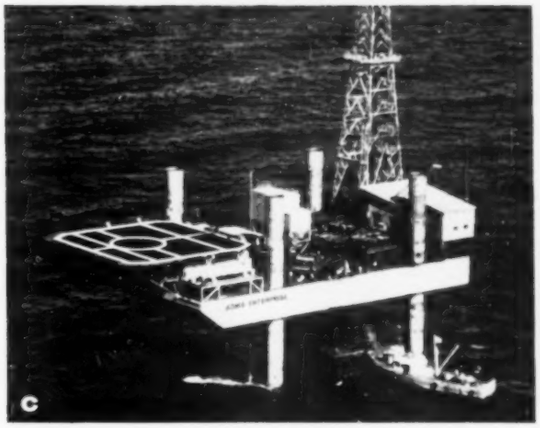

C

D

World-Wide... **DeLONG** spurs the offshore search for oil

The first mobile drilling platforms, used in the Gulf of Mexico, were pioneered by DeLong Corporation in 1953. Today, DeLong platforms are on the job drilling for oil in offshore locations throughout the world. These highly mobile, self-elevating platforms, designed by DeLong engineers, are built in both United States and European shipyards.

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A. *The first mobile drilling platform to operate in the Gulf of Paria offshore from Trinidad, B. W. I. was designed by DeLong engineers. Built in Germany in 1958, it is now engaged in an around-the-clock search for new oilfields for Trinidad Northern Areas, Ltd., jointly owned by Shell Texaco, Inc., Shell Trinidad, Ltd. and B. P. Trinidad, Ltd.*

B. *This DeLong-designed platform, capable of drilling in water up to 125' deep, is under lease to Pan American International Oil Company for use in the Persian Gulf. The 104' x 200' platform is equipped with truss-type legs, 225' long and 10' in diameter and has air conditioned living quarters for fifty men.*

C. *The ADMA Enterprise, designed by DeLong Corporation for Abu Dhabi Marine Areas Ltd., jointly owned by British Petroleum Company Ltd. and Compagnie Française des Pétroles, was the first mobile drilling platform to be used in the Persian Gulf. Fabricated in Germany, this DeLong platform was towed 7,000 miles to its Middle East site in 88 days.*

D. *Shown starting its 9,200-mile voyage from Southampton to British Borneo, the Orient Explorer will soon be operated by Brunei Shell Petroleum Co., Ltd. In the South China Sea. This 106' x 190' DeLong platform has air conditioned living quarters for fifty-six men.*

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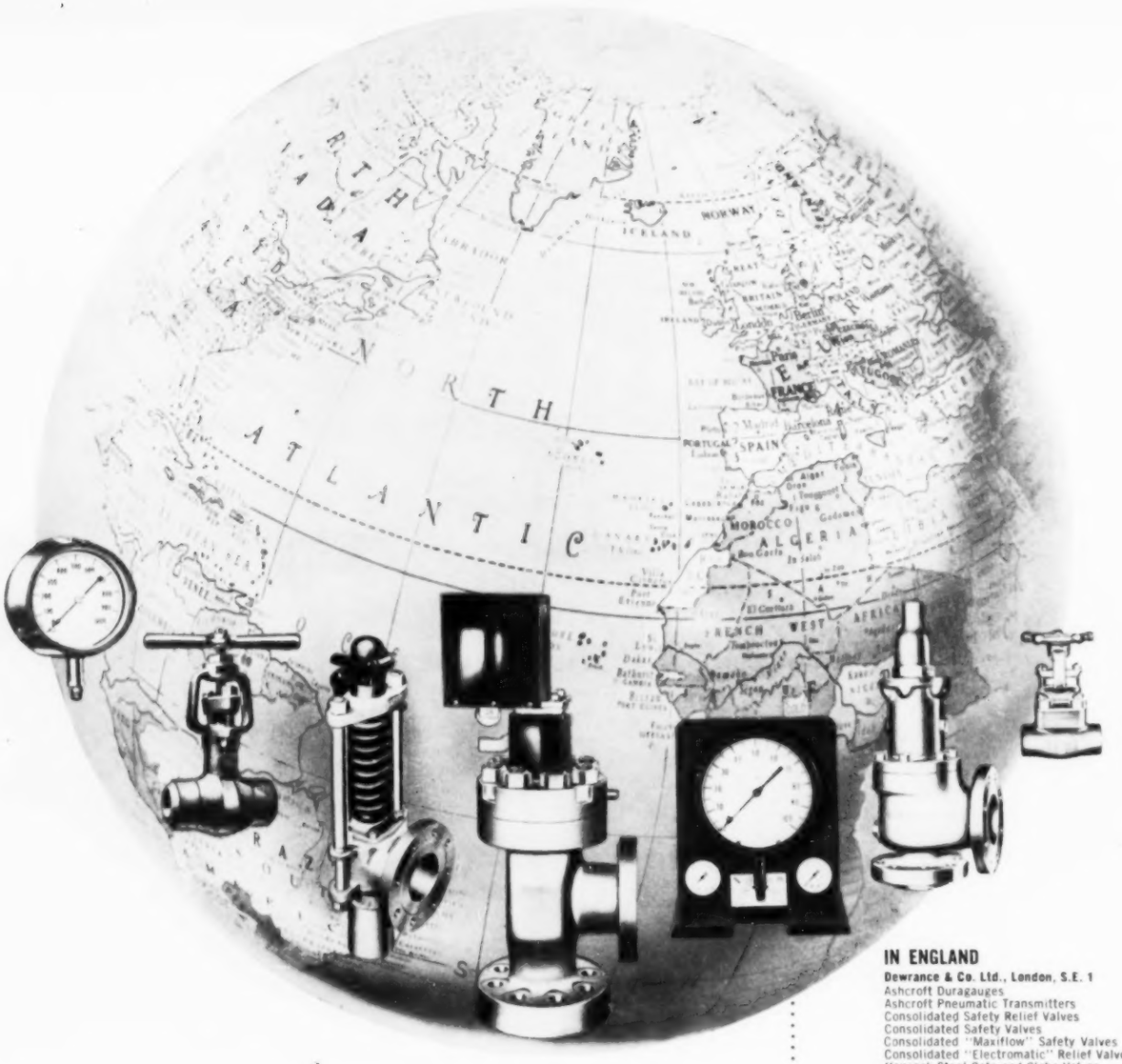

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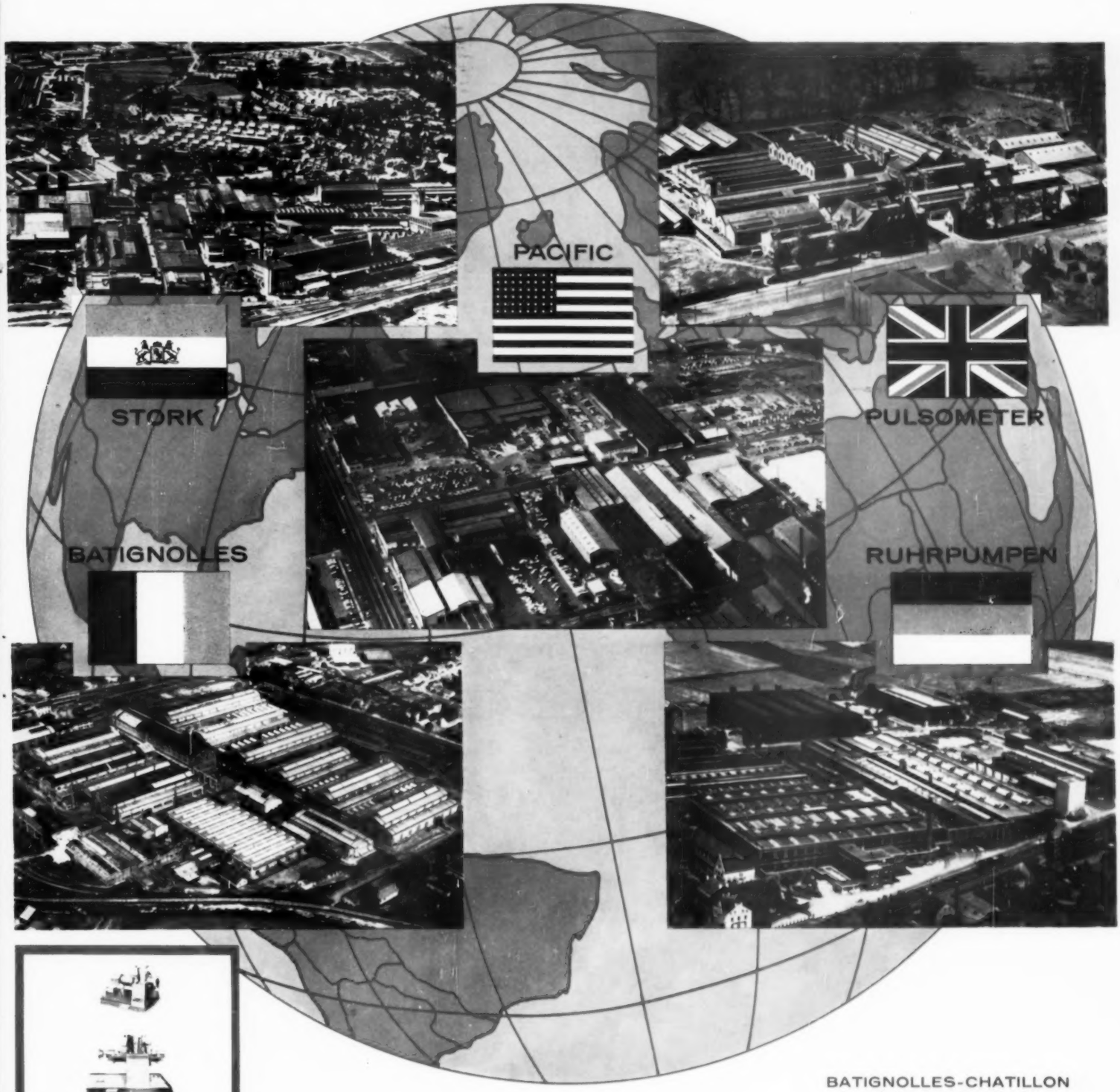

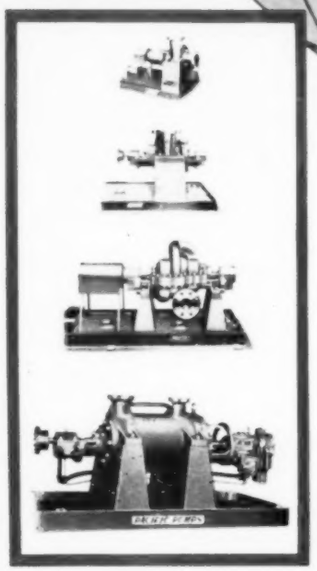

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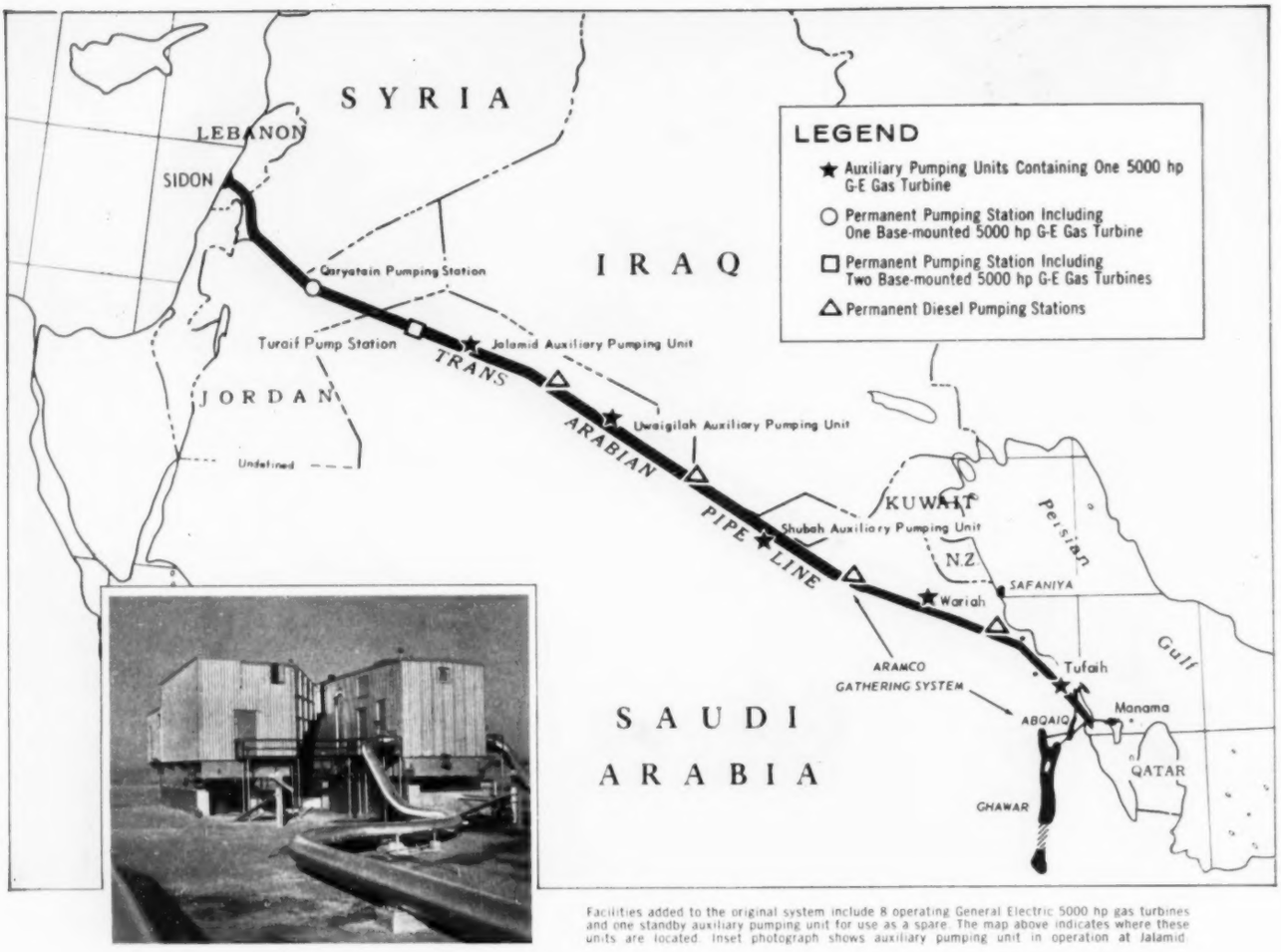

Facilities added to the original system include 8 operating General Electric 5000 hp gas turbines and one standby auxiliary pumping unit for use as a spare. The map above indicates where these units are located. Inset photograph shows auxiliary pumping unit in operation at Jalamid.

How General Electric helps increase pipe line capacity 40% on the 1000 mile Trans-Arabian pipe line system

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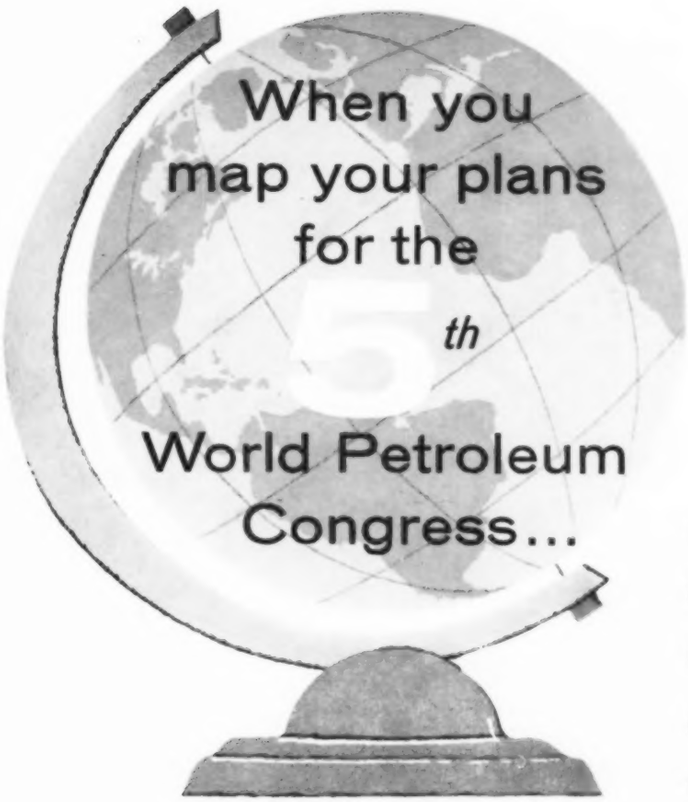

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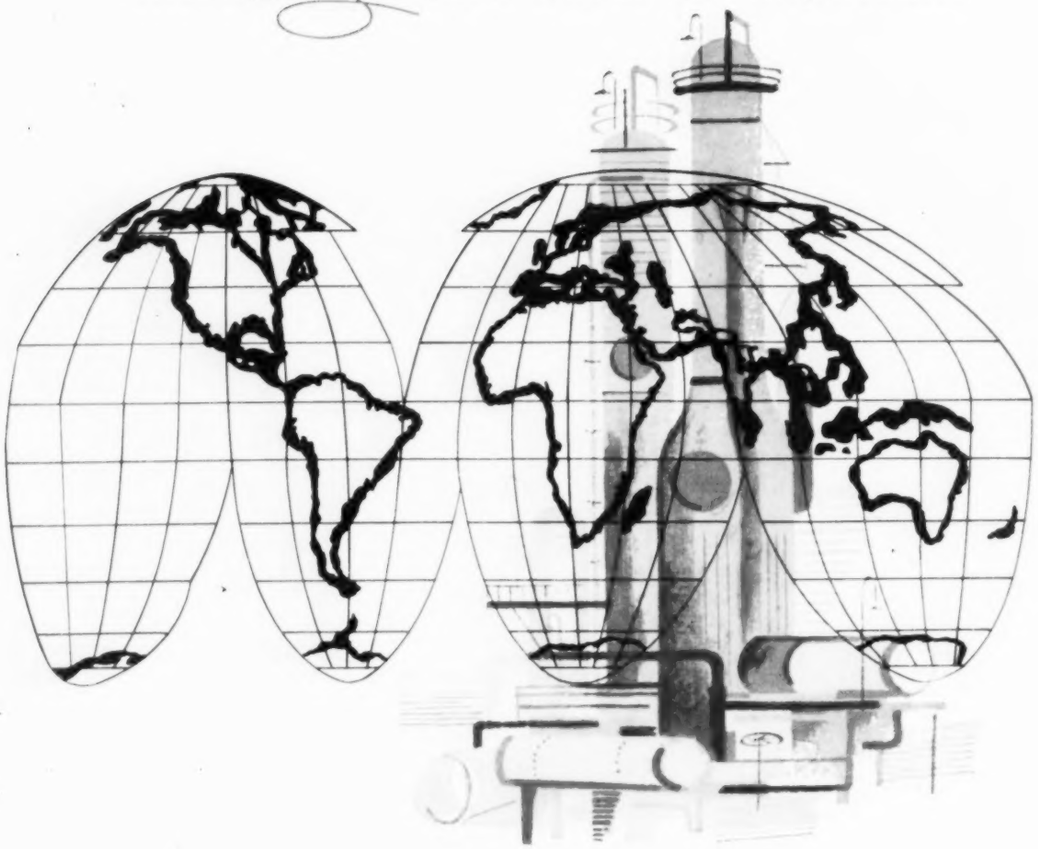

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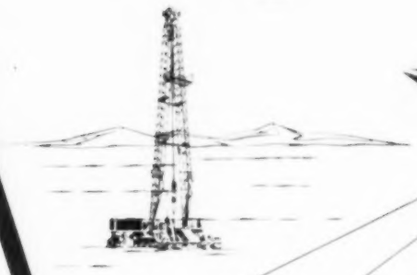

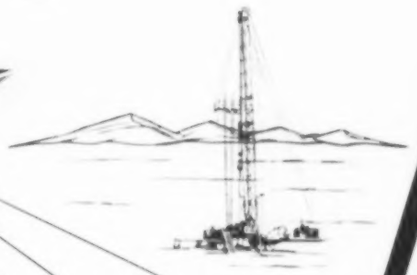

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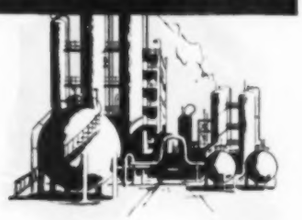

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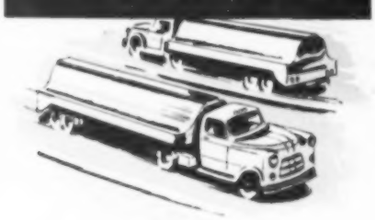

TIME HAS PROVED the exceptional durability of neoprene hose. Whether it's dock, curb pump, fuel oil or tank truck hose, performance records are convincing evidence of neoprene's extended service life. Neoprene tube resists deterioration from oil, gasoline or chemicals. Neoprene hose cover resists sunlight and weather, withstands rough handling that chips, cuts, abrades and causes flex cracking in ordinary hose.

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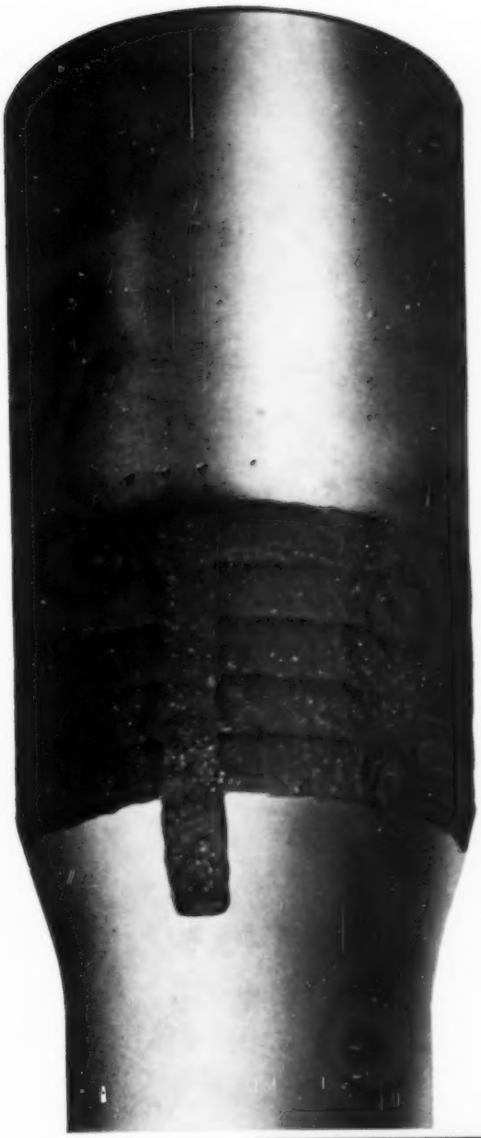

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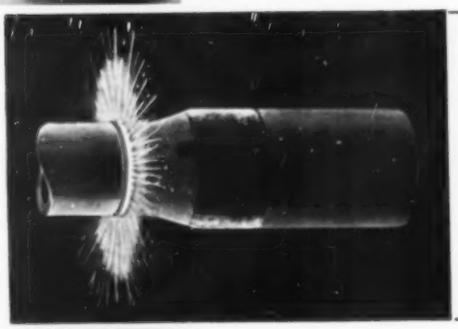
Since 1938, when Hughes introduced the first flash-welded drill string, *more than 40 million feet* of drill pipe have been unitized by the "Flash-Weld" process.

A new heat treating process has *more than doubled* the tension impact strength of "Flash-Weld" pipe connections. And new processing controls are improving the quality of the finished drill strings.

In addition to exacting physical tests, "Flash-Weld" tool joints and flash-welded connections undergo a series of critical inspections. For instance, after flash-welding, all weld areas are subjected to magnetic particle inspection. The critically-stressed areas of the tool joints themselves (this applies to all Hughes joints) are magnetically inspected. And the hardfacing on the joints is "snow" tested to check the bond of the hardfacing material to the joints.

The Hughes method of hardfacing, plus Hughes' specially developed tungsten carbide hardfacing material, assures maximum protection against wear during the life of the joints.

FLASH-WELD
A DEVELOPMENT
OF
HUGHES
TOOL COMPANY
HOUSTON TEXAS



Complete line of "Flash-Weld" joints is available for attachment to new API LIGHTWEIGHT drill pipe, as well as standard weight pipe. Ask your Hughes man.

"Flash-Weld" joints are available with tapered and square shoulders

A HARD HAT HANGS ON OUR HALL TREE

It's the hard hat of *experience* gained on rig floors throughout the world during the past 50 years.

It's *experience* gained in making rock bits that have drilled over two billion feet of hole.

It's *experience* gained in the research laboratory where for a half century we have studied the drilling characteristics of rock bits, the performance of materials, and tested the soundness of new ideas.

It's *experience* gained in making specialized tools for rotary drilling since 1909.

We wear our hard hat with pride . . . because it is a symbol of the countless rig floors trod by Hughes men . . . of the nights . . . the days . . . the months . . . the years that we have worked elbow to elbow with the men who have made drilling history.

HUGHES TOOL COMPANY

50TH ANNIVERSARY YEAR 1909 – 1959

Customers with Special Exchange Problems may now take advantage of CB&I's *Coin of the Realm* Plan

Coin of the Realm may be the answer to your Special Exchange Problem:

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CB&I's new *Coin of the Realm* plan makes it easier for customers with special exchange problems to take advantage of CB&I's world-wide engineering, fabrication and erection services.

This service assists CB&I customers in completing vital overseas expansion programs, *faster* . . . and it may provide welcome assistance in *instituting* needed expansion programs.

Various CB&I subsidiary companies are ready to complete transactions using *Coin of the Realm* currencies, shown at left. For further details on this unique program write the nearest CB&I office.

Chicago Bridge & Iron Company

P82CB

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- **REVERSE RISING REFRACTORY COSTS**

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REFRACTORIES COMPANY
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IN DEPTH!

FOR TEMPERATURES FROM 700°F TO 3600°F

MEX-R-CO

PROTECTION

Under These Service Conditions

1. Velocities of 130-feet, and above, per second, in dilute phase lines
2. Velocities above 8-feet per second in dense phase lines, or in dust collectors
3. Turbulent flows — or blasts
4. Coarse grain catalyst, equilibrium coke, or sinter dust
5. Abrupt change in direction or any combination of the above conditions
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MEX-R-CO service-proven, extreme erosion- and abrasion-resistant castables are high in purity, extra strong . . . and easy-to-apply. Service performance records indicate it is important to select the RIGHT Castable in the beginning and avoid the high cost of early repair and replacement. It does not cost more to employ the best. In-service time should be the deciding factor. For "Protection-in-Depth" use and specify MEX-R-CO Refractory Castables.

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This coupon will bring complete technical data on MEX-R-CO Refractory Castable Products. No obligation.

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Send complete information on Refractory Castable products for installation in (Type of Unit)

Have your engineer contact us.

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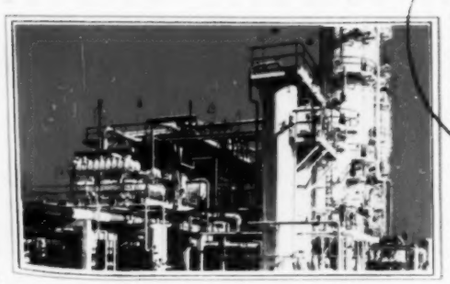
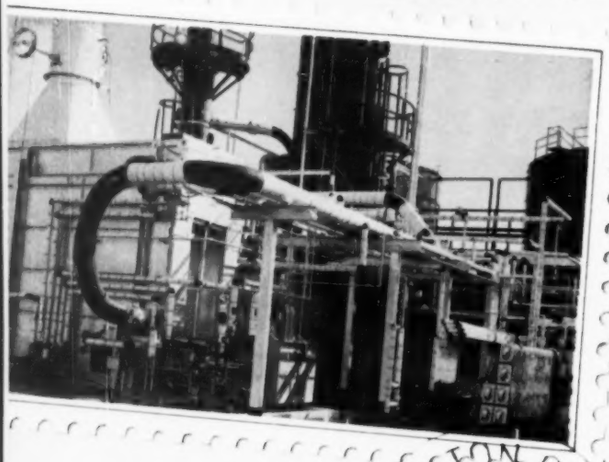


ITALY — 10,000 metric ton/yr phthalic anhydride plant now being handled for ACNA in Cengio.

Around the world, engineering projects of note bear the Badger Stamp

CANADA — tar distillation plant for Dominion Tar and Chemical Company, Limited, Hamilton, Ontario, Canada.



Badger affiliates and sales and field offices approach world-wide status. Through these well-established and rapidly expanding facilities, Badger is currently engineering and constructing more than twenty-five major projects for local, regional and international clients in the petroleum, chemical and nuclear energy industries.

Considering a plant project in this country? . . . or abroad? Call on Badger for proven ability and experience available on-the-spot . . . anywhere. For more information write or call today. Badger Manufacturing Company, 363 Third St., Cambridge 42, Massachusetts.

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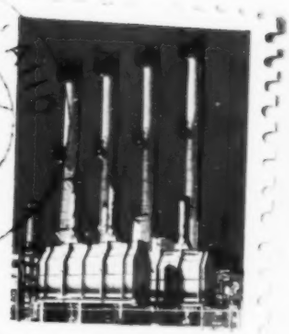
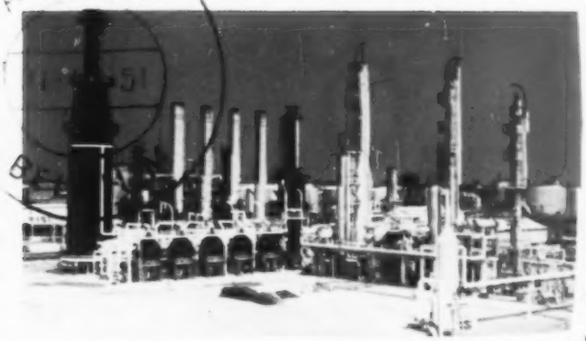




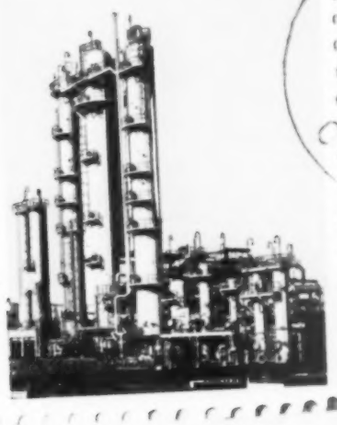
BELGIUM — Powerformer-Hydrofiner and miscellaneous offsite facilities recently completed for Esso Standard Refinery S.A. in Antwerp.

ARUBA — distillate treating unit for Lago Oil & Transport Company recently completed by Badger.

THE NETHERLANDS — complete 100,000 bpsd "grass-roots" refinery under construction for Esso-Nederland N.V. in Rotterdam.

TAIWAN — 600 bpsd sulfuric acid alkylation plant now under construction for Chinese Petroleum Corporation in Kaohsiung.

UNITED STATES — benzene unit engineered for Gulf Coast refiner. Produces 24 million gallons of purified benzene annually.



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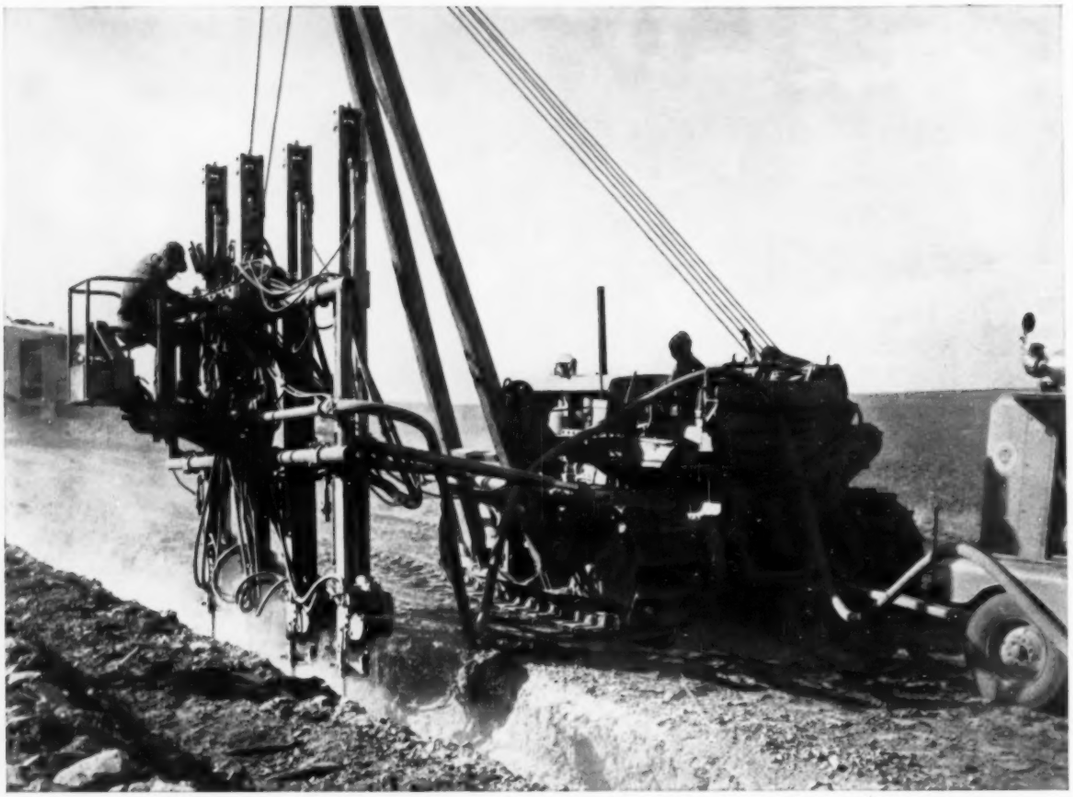
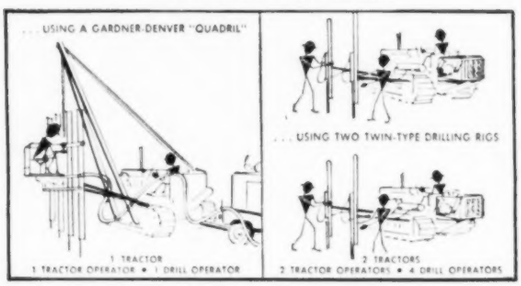


Gardner-Denver "Quadril" saves four men . . . one tractor

Fast blast holes, four at a time, with one man doing the work—that's what the "Quadril"* means in trenching rock. All four of the "Quadril's" fast-acting, heavy-duty rock drills are operated by hydraulic remote control—at the finger-tip command of one operator. Thus, the "Quadril" eliminates three drillers, tractor and tractor operator required for twin-drilling methods. Write for bulletin.

* Trade Mark

What it takes to drill four blast holes


. . . USING A GARDNER-DENVER "QUADRIL"
1 TRACTOR
1 TRACTOR OPERATOR • 1 DRILL OPERATOR
. . . USING TWO TWIN-TYPE DRILLING RIGS
2 TRACTORS
2 TRACTOR OPERATORS • 4 DRILL OPERATORS

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CRUSHING FORCE of earth-moving monsters, curves in a complex feasibility study, coursing of chemicals in a new process — these are elements of engineering know-how.

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Fish builds in all dimensions everywhere.

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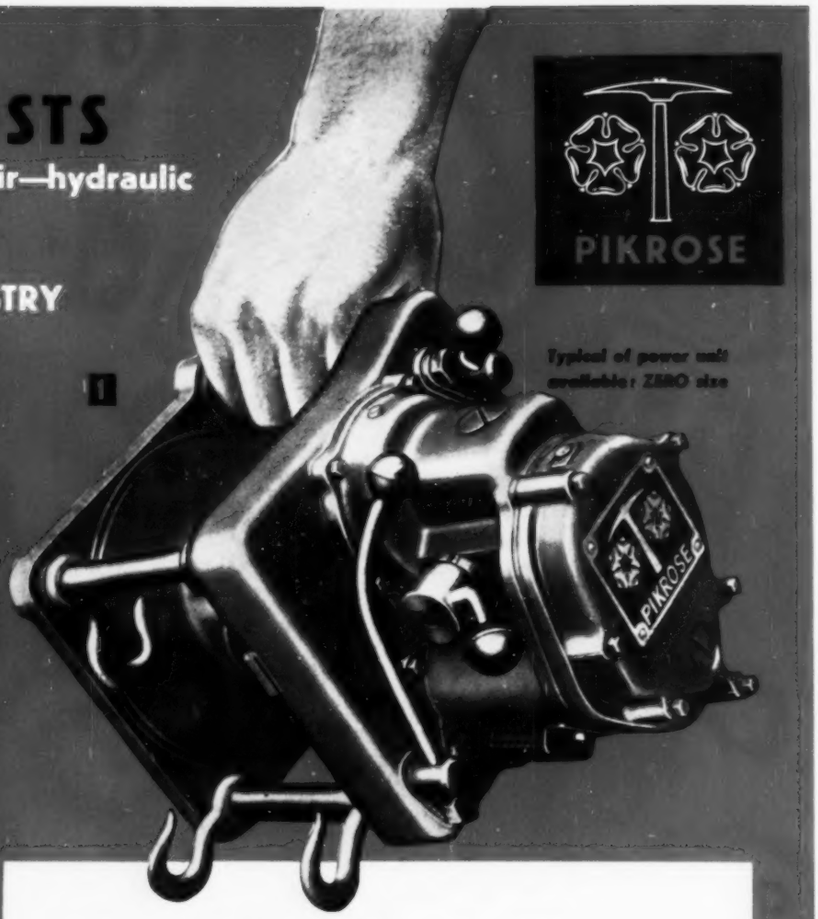
PIKROSE HOISTS

electric—compressed air—hydraulic

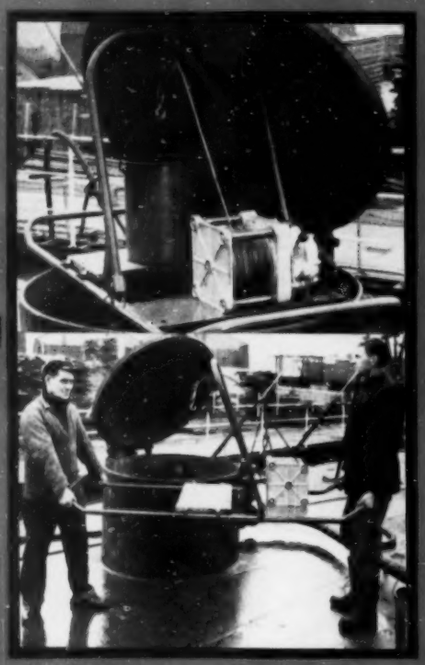
NEW APPLICATIONS within the OIL INDUSTRY

PIKROSE



Typical of power unit available: ZERO size

1



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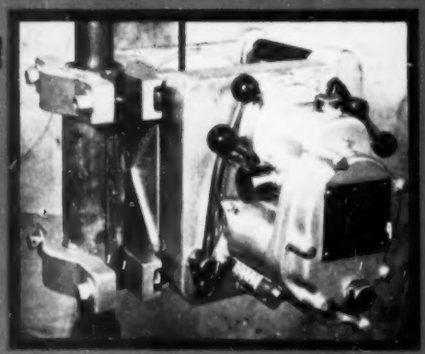

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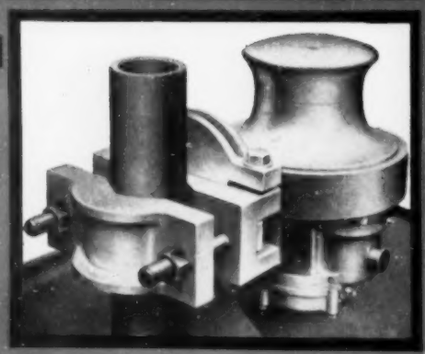


4

PIKROSE STANDARD HOISTS

The standard range of Pikrose hoists covers both electric and compressed air units from 3 h.p. to 45 h.p. continuous rating. In these hoists the prime mover, whether air or electric, is contained within the drum, making for clean and compact units. In the sizes 1 to 3 either single or two-speed gears are offered and both single and double drum arrangements are available.

Pikrose standard hoists are in use in metal and coal mines throughout the world as well as oilfields, civil engineering and industry generally.

PORTABLE POWER. These arrangements show the great versatility of the new PIKROSE ZERO size compressed air hoist.

1 SPECIFICATION. Normal Rope Pull at 80 p.s.i. 1650 lb. Average Rope Speed 60 ft. per minute. Rating 3 h.p. Drum Capacity 330 ft. of $\frac{1}{4}$" diameter rope (80% of calculated value). Weight with alloy casing 65 lb., with ferrous casing 94 lb.

2 Upon a light and portable stretcher-frame and placed conveniently on top of a coaming, it eases labour and reduces considerably the time taken to remove sludge from a tanker.

3 Clamped quickly and simply to posts or to existing davits aboard ship the ZERO SIZE forms an equally valuable hoist serving a multitude of purposes.

4 The ZERO size compressed air CAPSTAN hoist another form of portable power to which this model lends itself.

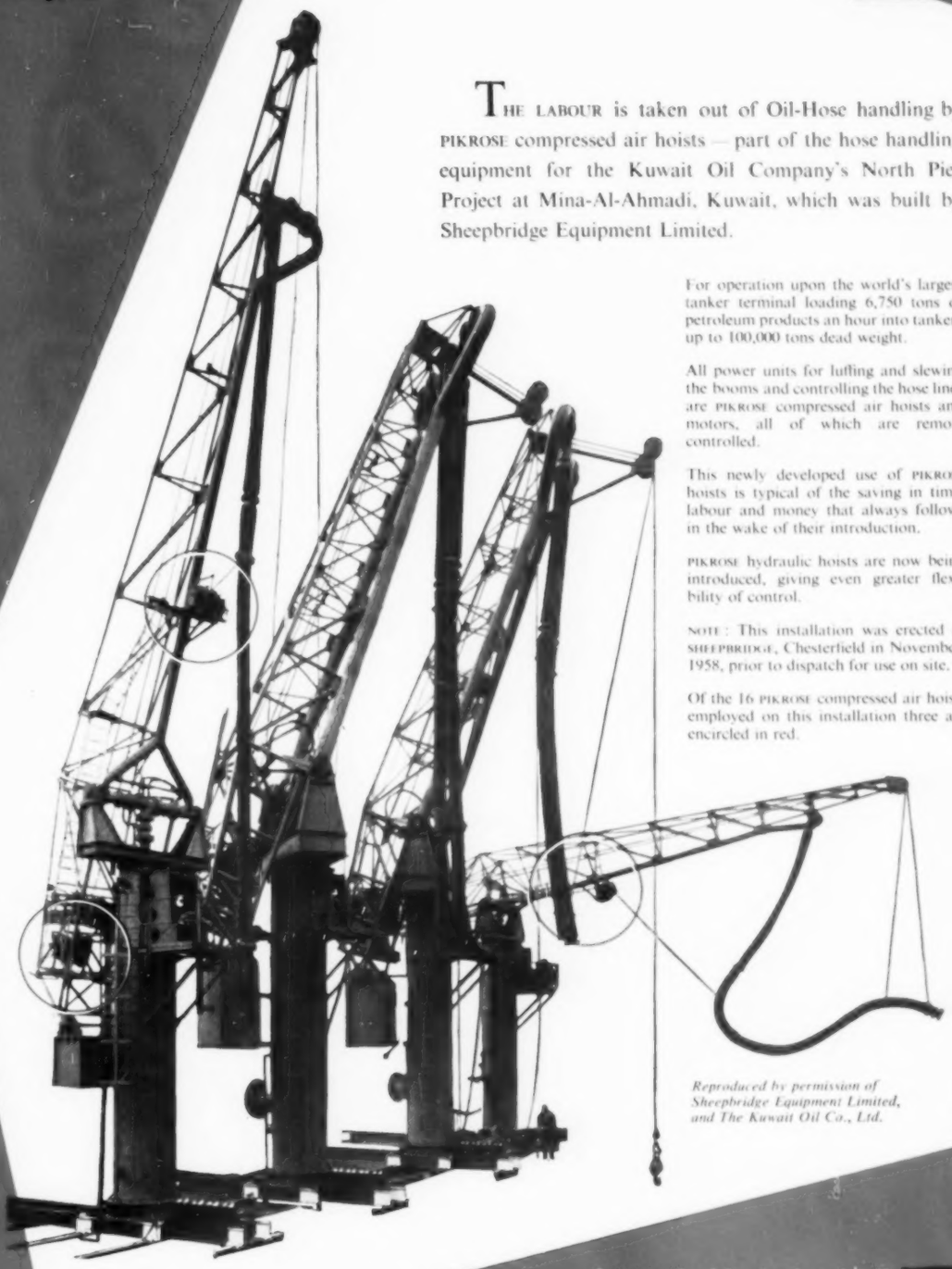
The multi-lingual abridged catalogue that is available on request.

AUSTIN HOPKINSON & CO. LTD.,

Association invited with an American company for manufacturing under licence, complementary products in the United Kingdom.

PIKROSE

THE LABOUR is taken out of Oil-Hose handling by PIKROSE compressed air hoists — part of the hose handling equipment for the Kuwait Oil Company's North Pier Project at Mina-Al-Ahmadi, Kuwait, which was built by Sheepbridge Equipment Limited.



For operation upon the world's largest tanker terminal loading 6,750 tons of petroleum products an hour into tankers up to 100,000 tons dead weight.

All power units for luffing and slewing the booms and controlling the hose lines are PIKROSE compressed air hoists and motors, all of which are remote controlled.

This newly developed use of PIKROSE hoists is typical of the saving in time, labour and money that always follows in the wake of their introduction.

PIKROSE hydraulic hoists are now being introduced, giving even greater flexibility of control.

NOTE: This installation was erected at SHEEPBRIDGE, Chesterfield in November, 1958, prior to dispatch for use on site.

Of the 16 PIKROSE compressed air hoists employed on this installation three are encircled in red.

Reproduced by permission of Sheepbridge Equipment Limited, and The Kuwait Oil Co., Ltd.

See overleaf for further details

DELTA WORKS · AUDENSHAW · LANCASHIRE · ENGLAND

PIKROSE

OTHER EXAMPLES CHOSEN FROM THE PIKROSE RANGE OF HAULAGES AND HOISTS

Two-speed, electric, compressed air or hydraulic

SIZE 1

Compact design gives this Size 1 two-speed hoist a five horse-power compressed air engine, enclosed within a drum having capacity for 225 feet of half-inch rope. In the most confined spaces, PIKROSE puts power at the end of a pipeline: a vertical lift of 2,950 lb. at 56 ft.p.m. or a 1,250 lb. lift at 122 ft.p.m.

SIZE 1

. . . WITH PERIGRIP AUTOMATIC REMOTE CONTROL BRAKES. Showing brake exposed.

SIZE 2

TWO-SPEED SINGLE DRUM HOIST

New Development:

The PIKROSE range with Automatic Hydraulic Transmission incorporating VICKERS-ARMSTRONG hydraulic and variable speed gear.

PIKROSE H.1. Automatic Hydraulic Haulage. Drum capacity (80% calculated value) = 384 ft. ¾" dia. rope. 2' 7" high 2' 11" wide 5' 1¼" long. Infinite speed control. Constant speed electric motor. Hydraulic drive preventing shock loading. Maximum torque at standstill. Smooth acceleration always.

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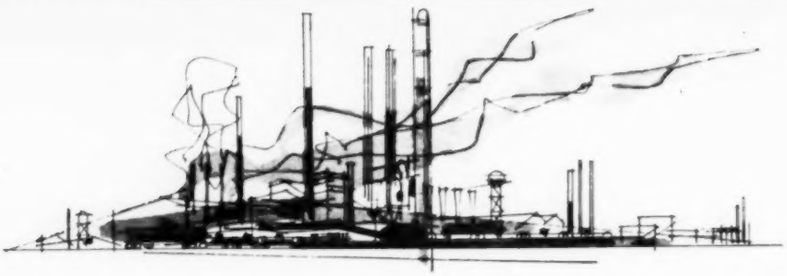
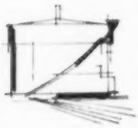


General American does a lot more than just build tank cars

General American's design, engineering, fabrication and erection facilities are available to solve many processing and storage problems. Here are some of the products and services offered.



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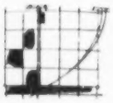

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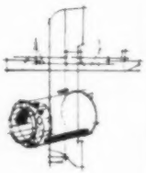

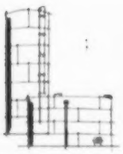

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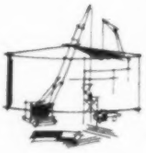

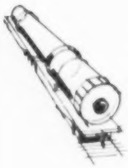

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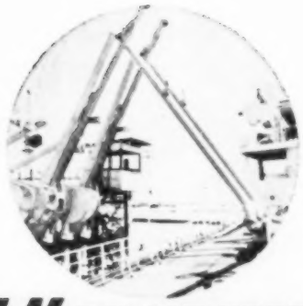

CHIKSAN MARINE LOADING ARMS

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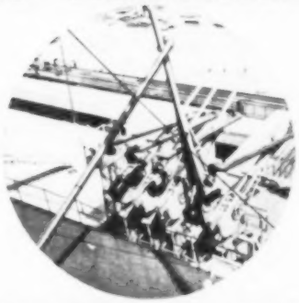

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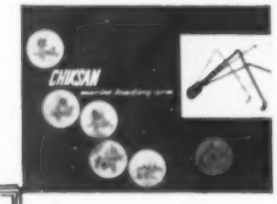

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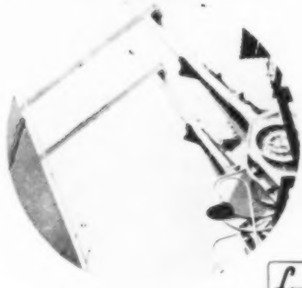

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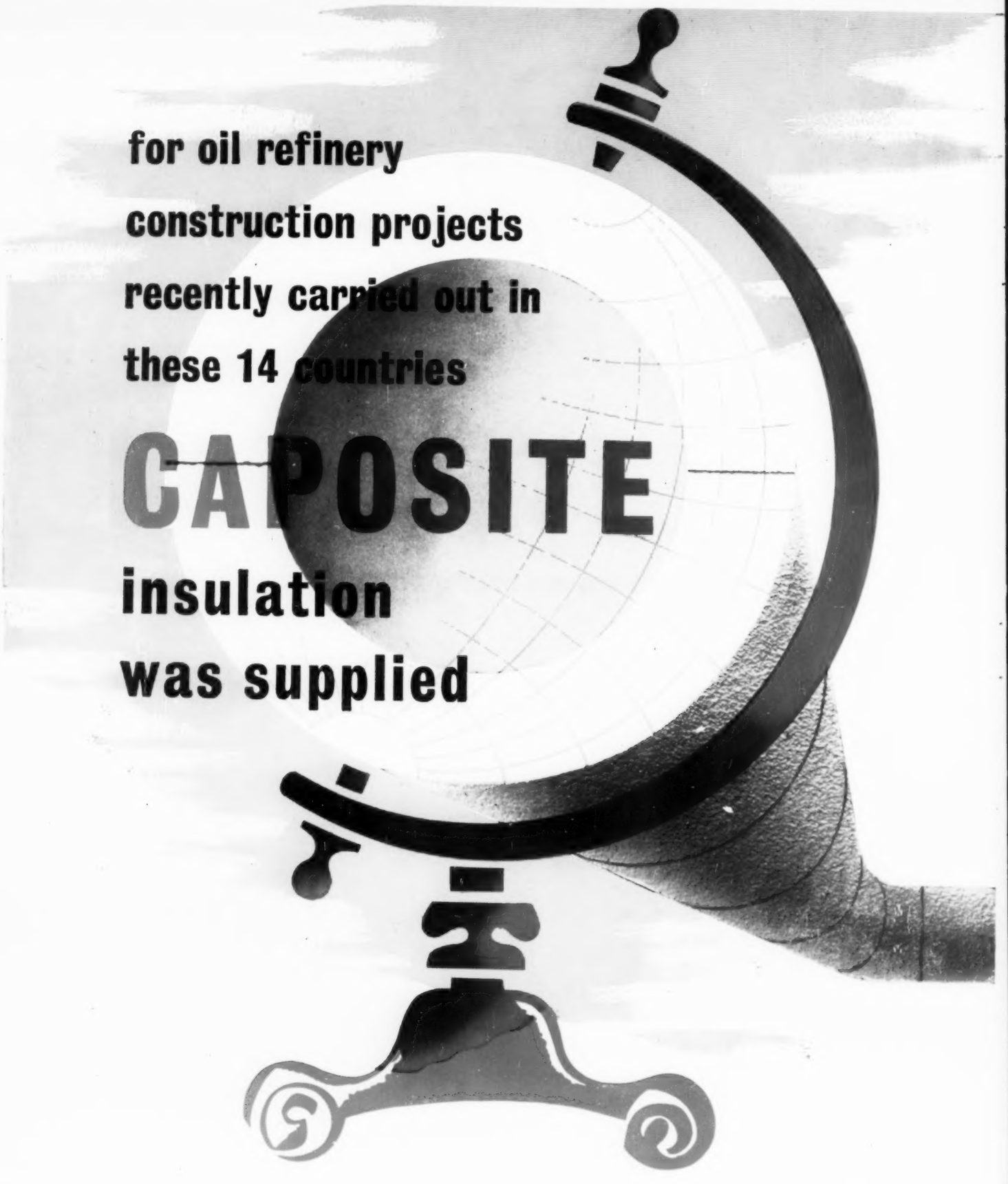
for oil refinery
construction projects
recently carried out in
these 14 countries
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insulation
was supplied

BAHRAIN *at Awali*
for Bahrain Petroleum Co. Ltd. Main Contractor: Foster Wheeler Ltd.

BURMA *at Syriam*
for The Burma Oil Co. (1954) Ltd. Main Contractor: Foster Wheeler Ltd. (London)

CANADA *at Clarkson, Ontario*
for British American Oil Co. Ltd. Main Contractor: The Lummus Co.

COLOMBIA *at Cartagena*
for International Petroleum Co. Ltd. Main Contractor: Bechtel Corporation (Insulation Contractor: Harold Aber & Co.)

ECUADOR *at La Libertad*
for the Anglo-Ecuadorian Oil Co. Ltd. Main Contractor: Procon (G. B.) Ltd.

ENGLAND *at Kent Oil Refinery*
for The British Petroleum Co. Ltd.

FRANCE *at Raffinerie de Normandie*
for Compagnie Francais de Raffinage. Main Contractors: Kellogg International Corporation and Foster Wheeler Ltd. (France). (Insulation Contractor: Soc. Technisol).

IRAQ *at Dawra, near Baghdad*
for Iraq Government Oil Refinery Administration. Main Contractor: Foster Wheeler Ltd. (London).

ITALY *at Genoa*
for Raffineria Dottore E. Garrone. Main Contractor: C. T. I. P.

KUWAIT *at Akmadi*
for the Kuwait Oil Co. Ltd. Main Contractor: Bechtel-Wimpey and E. B. Badger & Sons Ltd.

THE NETHERLANDS *at Pernis*
for N.V. de Bataafsche Petroleum Maatschappij.

NETHERLANDS ANTILLES *at C.P.I.M. Refinery, Curaçao*
for Royal Dutch-Shell Group.

SCOTLAND *at Grangemouth*
for British Hydrocarbon Chemical Co. Ltd. Main Contractor: E. B. Badger & Sons Ltd.

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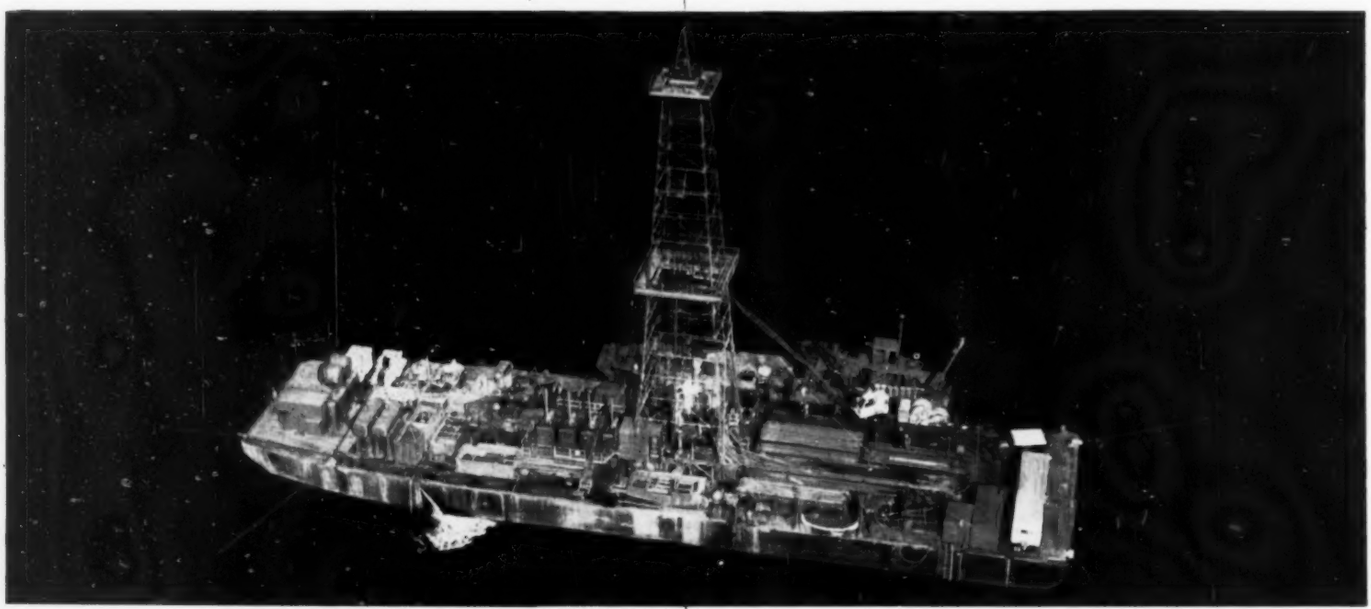
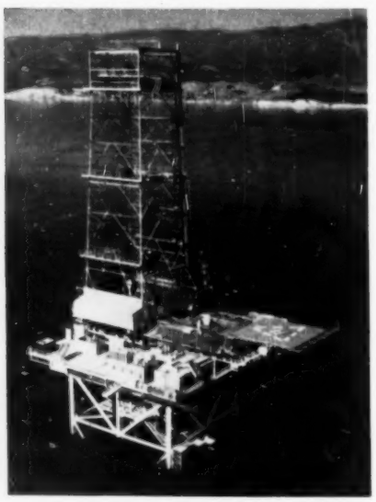


WODECO FLOATING BARGE OFF THE CALIFORNIA COAST.
OPERATOR—Phillips Petroleum Co. & Associates. BARGE—254 ft. x 68 ft. x 18 ft. steel. DERRICK—108 ft. steel designed to rack 10,000 ft. 3½ drill pipe in 60 ft. stands. DRILLING EQUIPMENT—one 12,000 ft. Diesel rig with a total of 2100 horsepower.



FIXED PLATFORM OFF THE CALIFORNIA COAST erected by Superior Oil Company of California and Humble Oil and Refining Co. PLATFORM—176 ft. platform permanently set in 100 ft. of water, 2-3 miles off the coast in open ocean with 147 ft. derrick. PROVISION for completion of 25 wells. DRILLING EQUIPMENT—two completely independent 12,000 ft. rigs powered by electric current from the shore.

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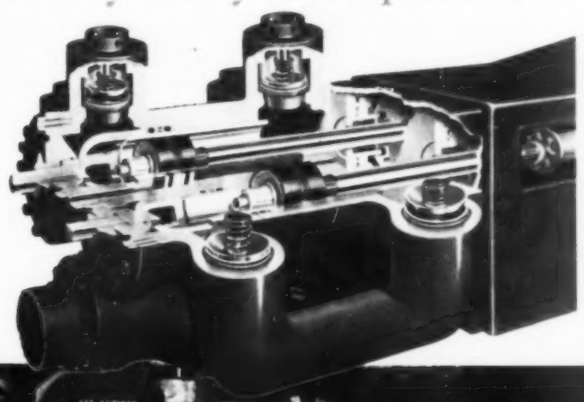
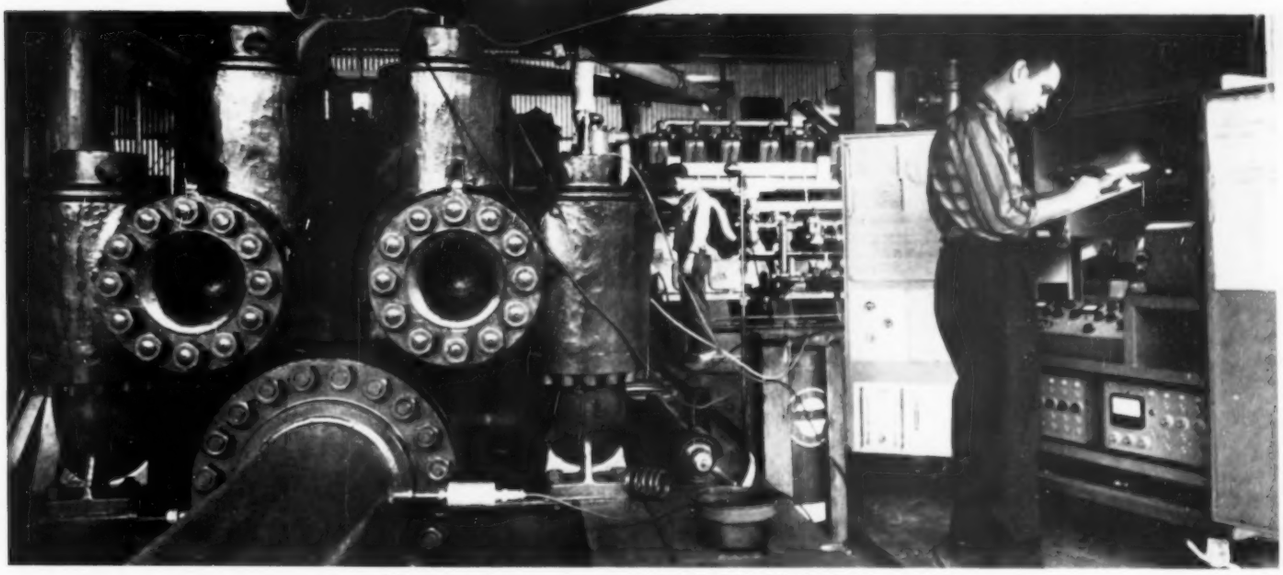
LONG BEACH, CALIFORNIA

THIS MAN, THESE PARTS,

put money in your pocket



This man puts money in your pocket. He's testing fluid end pump parts in our Houston laboratory. He finds out both in *our* laboratory and by thorough field testing what is needed to make a good part better in *your* pump. When you put Mission pump parts in your pump you can be sure they've been tested under conditions more difficult than any that will be found in actual drilling. Longer life, greater stamina have been designed in and built in to all Mission pump parts. These exhaustive tests mean that you can rely on Mission rods, liners, valves and seats, pistons, packing, springs for long life on the toughest jobs. This pump test laboratory is one more way we can be sure of our guarantee, one more way to insure that you get highest quality.



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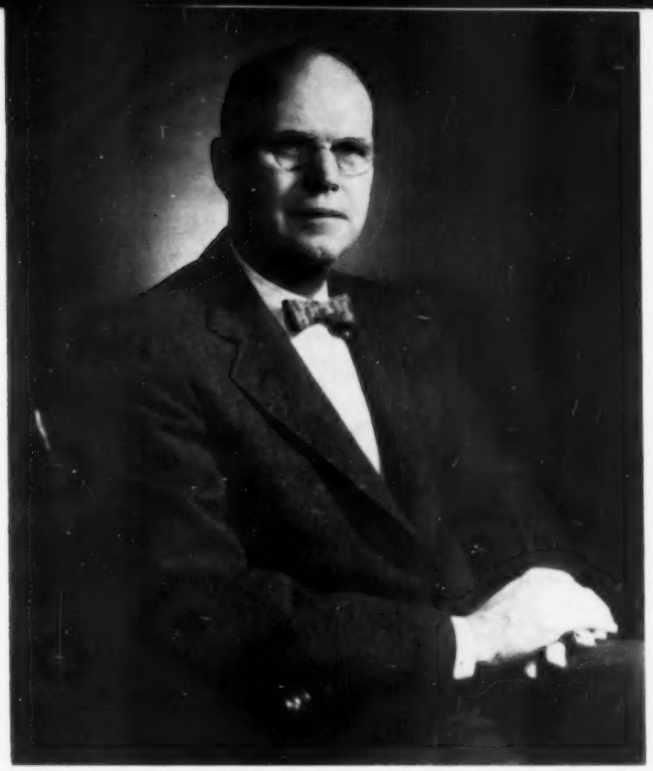


Dr. E. V. Murphree

H. M. S. Burns

Welcome to the Congress

THE convening of the Fifth World Petroleum Congress in New York, Sunday, May 31, will culminate two years of intensive preparation by oil men around the globe.

The extent to which the international oil industry has cooperated in the arrangements for the meeting is reflected in the size and scope of the technical program which has been developed. Over 100 technical sessions are scheduled at which 300 papers will be presented on subjects covering all the activities of the petroleum industry except marketing.

It is in the tradition of the world organization to invite one of the industry's leaders to become president of the congress being held in his country. As such, he presides over the more important functions associated with the meeting. H. S. M. Burns, chairman of the board of directors of the American Petroleum Institute and president of Shell Oil Co., has accepted this office for the fifth congress. Those who know Mr. Burns will acknowledge the wisdom of this choice, as it would have been difficult indeed to find anyone more fitting to fill the role.

Credit is due to the scores of people in many countries who have voluntarily devoted their time and professional talents to organizing the congress program. Their efforts have been coordinated by the Fifth World Petroleum Congress Inc., incorporated two years ago to work out the mass of detail associated with planning a meeting of these proportions. Heading this corporation as chairman of its board of directors is Dr. E. V. Murphree, president of Esso Research and Engineering Co., who is not only an internationally recognized authority on petroleum science, but has achieved considerable prominence in the development of atomic energy. He has a dual congress role in that he is also chairman of the Permanent Council of the World Petroleum Congress, the policy-making body of the organization which insures its continuity, decides the locations of successive congresses, and sees to it that their high technical standards are maintained.

The task of organizing the congress has been no light one, but the diversity and breadth of the program will most assuredly justify all the painstaking effort which went into its preparation.

By its initial and continued support of the congress, the world oil industry has long since given the accolade to the founders of the organization who had the foresight 25 years ago to recognize the importance which the international exchange and discussion of research and operational data would assume as the industry expanded and the determination to establish the World Petroleum Congress to provide the necessary facilities for such exchanges to be possible. Such vision has given the industry its vitality and resilience over the years—may it always be so!

USA oil looks back with pride
and forward with confidence

CHANGE AND GROWTH

by Frank M. Porter
President, American Petroleum Institute

IN 1859, the English naturalist, Charles Darwin, published *On the Origin of Species by Means of Natural Selection*, one of the major scientific events of the century. In the United States, in the same year, a former railroad conductor named Edwin L. Drake made a discovery of a different kind. He drilled a well, near Titusville, Pa., which struck oil at a depth of 69½ ft, the first successful well drilled in the USA to produce petroleum. The Drake well began a new era in history—the era of cheap abundant energy from liquid fuel. It gave birth to an industry which has become the third largest in the United States—outranked only by agriculture and the combined utilities—an industry which is proud this year to honor the man who completed the first oil well on August 27, 1859.

The coincidence of these two events—the publication of Darwin's revolutionary theory and the birth of the USA oil industry—is interesting. Of all the enterprises which have existed within the past 100 years, none has demonstrated more vividly than oil the capacity to adapt successfully to changing conditions, the principle which was so important to Darwin's theory.

Consider how the oil business has adapted itself to change. It started as a supplier of kerosine for lamps. Just over a half-century later, its principal product was gasoline for automobiles. Today, with the introduction of jet transport planes and experiments with new automobile engines, kerosine is growing in importance again. The new science of petroleum chemistry, moreover, has made oil a source of raw materials for thousands of other products.

There have been other changes. Natural gas, first used for illumination and later as a fuel, is now a rich source of petrochemicals as well. Because reserves of crude oil are becoming more costly and difficult to find, oil companies are carrying forward research which will enable them to extract liquid fuel from shale and coal.

As the economic patterns of the nation have changed, the structure of the business has changed too. Started by independent

enterprisers, oil soon became a big business in an era when large combinations in various fields were organizing America's vast industrial growth. But even before the breakup of The Standard Oil Co., many independent oil companies were competing freely, each playing an essential part in its own segment of the business. The oil business today is carried on by many large companies, a great many medium-sized companies, and thousands of small companies.

Oil has had to adapt itself to changes in government attitudes toward business. Relatively unhampered and lightly taxed at the outset, oil has become a prime target for harassment by regulatory agencies and also serves not only as one of the nation's largest taxpayers, but as a collector of increasingly burdensome consumer taxes on its principal product.

With all the changes to which oil has successfully adapted itself, it is not surprising that oil men themselves have changed. The first oil men who followed Colonel Drake to Titusville were adventurers. The feverish business in which they engaged has been described by Mark Sullivan as "chaotic . . . characterized by a lack of orderliness, a prince-today-and-pauper-tomorrow industry . . . in which chance was the largest element, in which calamity was forever just around the corner and did not always keep itself there."

The oil man of today is a responsible businessman who is aware that his decisions concern not only himself, but many people as well. He may be an independent producer, refiner, transporter, or marketer, or he may be an employee of a company owned by thousands of stockholders.

One quality today's oil man has inherited, however, from the pioneers of the western Pennslyvania oil region is the taste for freedom—to take a risk, to earn a profit, to compete for the favor of the consumer. He is convinced that, without this freedom, his company would not be able to operate efficiently, to carry out its obligations, and to supply people with an abundance of good products at competitive prices. He is concerned when he sees that freedom being menaced by further government restrictions, as it often is these days.

For evidence of what the oil business can achieve in a free society, the modern American oil man need only point to what has already been accomplished. Possessing only one-tenth of the world's areas favorable for oil and gas accumulation, the USA today produces two-fifths of the world's petroleum annually from more than half a million wells. More than 42,000 separate companies in the USA are currently engaged in producing, refining, transporting, and marketing more than 9,200,000 bbl of oil a day. In recent years, virtually the entire increase in the energy consumed in the United States has come from oil and gas, with the result that petroleum now supplies more than two-thirds of USA energy needs. Machines, which did just over a third of the physical work in the United States at the time of Drake's discovery, now do almost 99% of our work. Many of them are fueled by petroleum—and all of them, of course, are lubricated by it.

There are many individual achievements to which the American oil man can point with justifiable pride—steady advances in refining technology, which have kept improving the quality of motor fuels and increasing the yield of gasoline from crude oil; the development of ingenious new secondary-recovery methods, which have extended our reserves; the growth of our pipeline network—now more than 200,000 miles—and the introduction of automatic controls for greater efficiency; the launching of bigger, faster, more economical tankers; the building of modern service stations for the greater convenience and comfort of motorists.

Important as these achievements are, they are means, not ends. The end-product of our activities is still, as it was in 1859, an abundance of low-cost energy from liquid fuel. When the oil business started, that meant illumination for homes where people had gone to bed at sundown, so costly were the whale-oil lamps and candles previously in use. Soon it meant cleaner and easier cooking. In the early years of this century, it meant power for the horseless carriages and flying machines which were being built. It was a decisive factor in two world wars.

Of all these elements, it is motor transportation, of course, which has had the greatest effect on the lives of the American people. As interested as we Americans are in automobiles, I think we tend to forget how revolutionary their effect has been. The very change of the name from "horseless carriage" to "automobile" is significant. Because the original name signified a substitute for the horse-and-carriage, it suggested that the vehicle would be driven only by the well-to-do. But the new invention soon became more than a convenience for the "carriage trade." In just half a century, motor transportation has converted the USA into a nation of families of whom a majority own their homes and live in comforable, healthful surroundings conveniently near urban centers; brought outdoor recreation within the reach of all; transformed the distribution and marketing of food and other retail products; made possible the building of consolidated schools in rural districts; increased the efficiency of fire protection and emergency medical care; freed housewives from the confines of their homes and enabled them to pursue stimulating activities during the day; and brought mobility to millions on a scale which was undreamed of in the days of the horse and buggy. The automobile revolution could not have occurred without ample supplies of low-cost energy. American oil men are proud they have been able to supply it.

Since World War II, the oil business in the USA has had one of its greatest periods of growth. Domestic demand has been increasing for 16 consecutive years. Annual production of crude oil and the total of proved reserves, each has risen approximately 50% since the end of the war. Annual capital expenditures have tripled.

Yet, during this same period, the USA proportion of world crude production has been steadily declining. In 1945, we produced two-thirds of the world's crude oil. Today, we produce just over one-third annually.

The decline in USA drilling activity and production in the past two years is only a minor and, we trust, temporary factor in this changing relationship. Of greater significance is the vast increase in production by the rest of the world. Last year, it passed the $3\frac{3}{4}$-billion-barrel mark—over $4\frac{1}{5}$ times as much as production at the end of World War II. Consumption outside the United States has almost doubled, just within the past decade.

When he sees these tremendous advances in foreign production and consumption, the American oil man likes to point out that a large part of the activity is carried on with know-how, equipment, and capital exported from the United States. Moreover, he takes a certain pride in the reputation that his colleagues have made as unofficial ambassadors of good will in many countries. He is also aware that the more rapidly friendly nations catch up with the United States in industrial development, the greater will be the opportunities for world trade—which will, in turn, stimulate business in the United States as it will everywhere else.

American oil men, in any case, are optimistic about the second century of their industry. By 1967, it is expected that USA demand will reach 14.4 million barrels of oil a day, an increase of more than 63% over the current level. Demand in the rest of the Free World is expected to more than double in the same time. Capital expenditures by the USA industry to meet increased demands are expected to total $77 billion in the 10-year period 1958-1967. For the rest of the Free World during that period, capital expenditures are expected to reach $63 billion.

These investments are likely to produce benefits of many kinds—more petrochemical wonders, improved fuels and lubricants, more efficient refining processes, more economical transportation, better service stations. The largest part of the investment, as it has up to now, will go into production. In 1957, for the first time since the end of 1946, USA proved reserves of petroleum showed a net decline, a reflection of the increasing cost and difficulty of finding new fields, among other factors. Besides development of methods of refining shale and coal, the American industry can be expected to go on perfecting techniques of offshore drilling and deep drilling—both extremely expensive operations.

There are many problems ahead for oil men, as our industry begins its second century. I am confident they will be solved—provided the USA oil business is permitted to go on functioning in the climate of freedom which made possible the remarkable achievements of its first 100 years. END

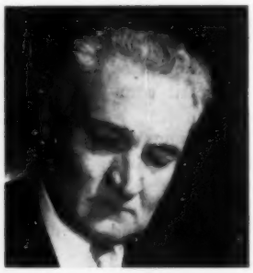
Who's who at the World Petroleum Congress

PERMANENT COUNCIL

1 E. V. Murphee

2 Sir S. Gibson

4 H. S. M. Burns



5 René Navarre

6 C. Padovani

7 G. Schlicht

11 S. J. M. Auld

13 H. Kupper

16 P. Erculisse

17 E. P. Malschaert

18 G. W. Gurd

19 M. S. Scheer

20 H. Weiss

21 G. Roberti

22 T. A. Salvadori

24 H. Ter Meulen

25 W. James

26 A. Bentz

27 K. Ziegler

28 E. B. Evans

ITS relaxed atmosphere belie the years of organization and effort which go into preparation of every World Petroleum Congress. The basic procedure and organizational structure are designed to provide a continuing entity. The Permanent Council, for interim periods between congresses. An operating entity, The Fifth World Petroleum Congress Inc. lives only to prepare the congress and handle actual operation of it.

Permanent Council: As the basic and only enduring ingredient in the World Petroleum Congress' organization, the Permanent Council comprises representatives from technical societies and professional groups in 12 countries. During the four years which elapse between congresses, it plans ahead for the next. While an actual congress is under way, it has only advisory functions. Chairman of the Permanent Council (as well as president of the operating group, the Fifth World Petroleum Congress Inc.) is Dr. E. V. Murphree.

Congress Committees: Through the Permanent Council, a system of national committees is maintained. They number 36 at present and include most producing countries as well as many which have no petroleum production. These committees are not permanent; they exist to stimulate interest in the congress within their respective countries, and to collaborate with

the organizing committees in New York to formulate plans for the congress, and then are dissolved. Their assistance is particularly valuable in soliciting papers (a total of about 285 will be presented at this congress, selected from a much larger number).

Actual direction of the congress during its sessions is through the Fifth World Petroleum Congress Inc. Its offices are located at 527 Madison Avenue, New York, and it is under the chairmanship of E. V. Murphree, who is also president of the Fifth World Petroleum Congress Inc. There are two principal adjuncts to this directive body; the advisory committees (not board members) which cover legal, public relations, and technical publications fields; and the board committees (members of the board of the Fifth World Petroleum Inc.) which consist of the program coordination, financial, and exposition committees.

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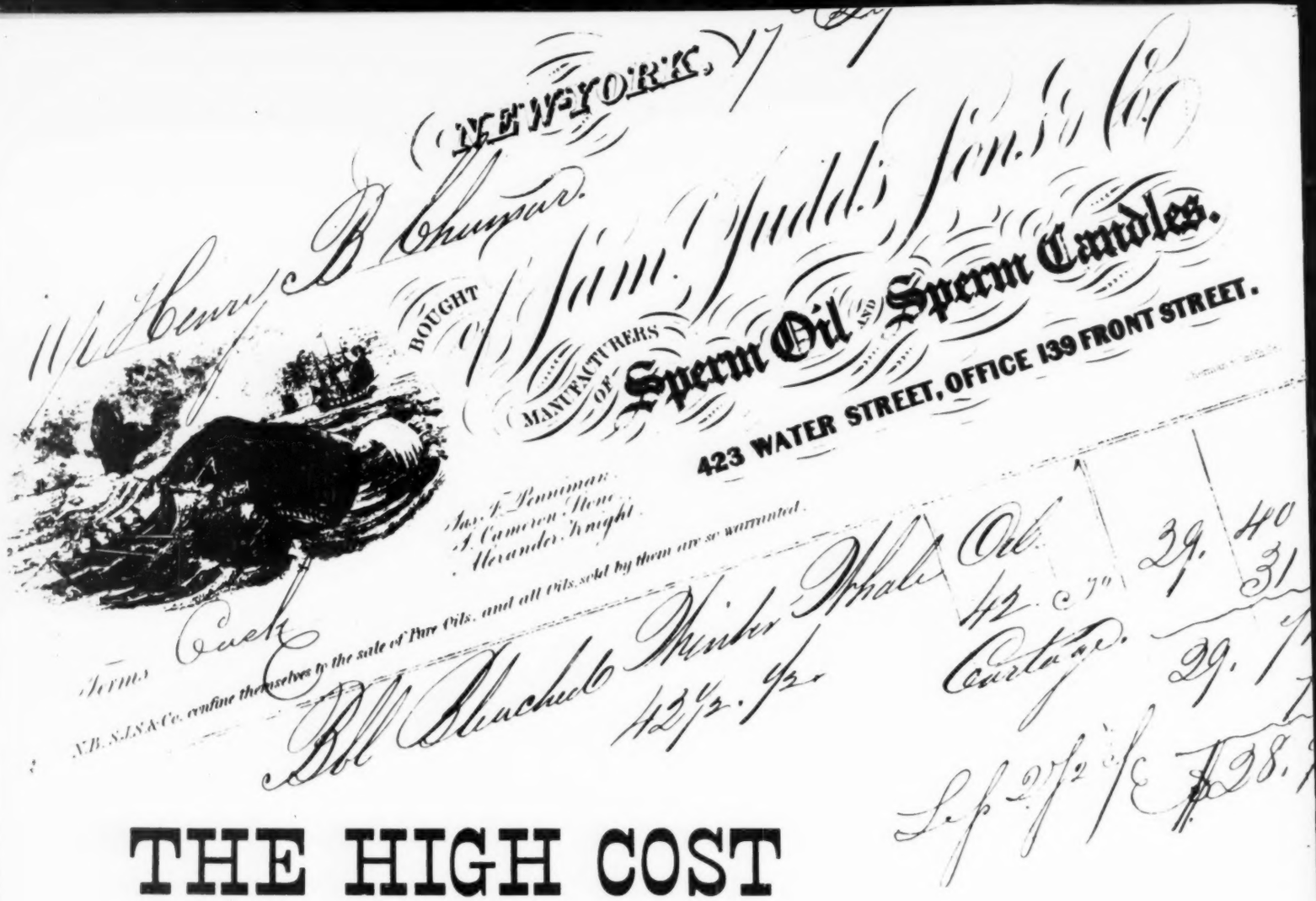
(Photographs were unavailable at press time for Numbers 8, 9, 10, 12, 14, 15, 23, 31, 32, 33, 34—Editor.)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THE HIGH COST OF WHALE OIL — *and what it led to*

by Kendall Beaton

A thriving refining industry preceded Drake, providing the new petroleum producers with a ready-made market. This interesting but long-forgotten chapter in oil's early history is brought to life with much new material not previously printed.

OIL historians commonly date the birth of the modern petroleum industry from an August afternoon in 1859 when "Colonel" Edwin L. Drake brought in a small, shallow well at Titusville, Pa. Persons aware that peroleum was known and used in other parts of the world before 1859 are sometimes puzzled to explain the uniqueness of the Drake well.

Drake, like Columbus, was not the first in his field; there were many Leif Ericsons of the oil business. But Drake's discovery, like that of Columbus, came at a time when the world was ready for it. Immediately hundreds of others followed his example, resulting in the launching of the modern petroleum industry forthwith.

This quick start was possible because facilities to convert petroleum into saleable products already existed in large number. During the decade before the Civil War, a new industry devoted to refining "artificial" lubricants and illuminating oils had grown mightily. It was, in fact, the profitability of this hydrocarbon oil trade which had given Drake and his backers the stimulus to seek out a "petroleum spring" in the back country of Pennsylvania and drill what was, for its day and depth, an expensive oil well.

By the end of 1859, *Scientific American* was able to count more than 30 "coal-oil" refineries in New England, New York, Pennsylvania, West Virginia, and Ohio. And their product, kerosene, was in such brisk demand at $1.50 a gallon that, before another 12 months were out, the number of these new plants would be doubled with a total of $6 million invested in them.

For more than a century, men of an inventive turn of mind had been proposing substitutes for whale oil, the Western World's most satisfactory illuminant and lubricant. Oil shales, cannel coals, byproduct coal tar from gas works, natural asphalt seepages, even crude oil from some of the older fields of Europe—all had been explored as raw materials for producing "artificial" oils by a variety of processes. And natural oils distilled from fish, from vegetable seeds, and from forest products all appeared briefly on the scene. But whale

oil—particularly the superior oil made from the head of the sperm whale—remained undisputed king of the market because of its more satisfactory qualities for lamps and lubrication. It is likely that whale oil might have retained this position of supremacy for several decades longer, retarding thereby the birth of the petroleum industry, except for one thing: the price of whale oil was rising to prohibitive levels.

For five centuries, ever since the late Middle Ages, western Europe had relied for whale oil on the efforts of a long succession of whalers—Basque, Dutch, French, English, Scandinavian—each giving place to successors as they worked out their nearby waters. By the late 1700's, the center of the whaling industry had shifted to the British colonies of the New World. Here, repeating the experience of their European forebears, American whalers first exhausted the whale population off their own shores and undertook progressively longer voyages, inaugurating the big whale hunt which is today remembered as the "Golden Age of Whaling" in New Bedford, Gloucester, Nantucket, in Massachusetts; Stonington, New London, in Connecticut; and Sag Harbor, N. Y. As Yankee whalers extended their reach from Brazil and the South Atlantic around the "horn" into the Pacific and as far as the Japan Sea, prying into every nook and cranny of the world which might hide a whale, voyages became longer and more expensive, with vessels staying out of port two years and more.

The price of whale oil increased steadily, and so did the size of the whaling fleet. By 1846, the American whaling fleet numbered some 735 vessels, whaling captains were building stately mansions from the profits of a single voyage, and the price of sperm oil had passed $2.00 a gallon, with good prospects of going as high as $5.00. This new era of seemingly endless prosperity for whalers was, like many another "golden age" before and since, a signal of the beginning of the end. Given the incentive of rich rewards for success, the hunt for substitute oils now began in earnest all over the Western World—as isolated inventors, working in ignorance of one another, searched for oils which would perform as well as whale oil but be much cheaper in price.

One of the substitute illuminants which had been produced sporadically during the 1830's and which gained in popularity during the 1840's as whale-oil prices went higher, was camphene, a purified oil of turpentine distilled over quicklime to free it from resin. It had a tendency to smoke in the ordinary chimneyless lamps of the day, and was usually mixed with two or three parts of alcohol, which had good burning properties but gave off little light. The resulting mixture, called "burning fluid," was highly volatile, extremely flammable, and had a disturbing tendency to explode. But its low price (somewhere between 65¢ and 75¢ a gallon in the early 1850's when sperm oil cost $2.50) was incentive enough to bring about its widespread manufacture in America.

KENDALL BEATON, former newspaperman and trade-magazine editor, has been with Shell Oil Co.'s public-relations department for 15 years. This article is based on his 1955 monograph, *Dr. Gesner's Kerosene, The Start of American Oil Refining.*

Europe favored as a substitute colza, or rapeseed, oil pressed from the seeds of a cabbage-family plant. Colza oil had the safety of sperm oil and produced a light nearly as good; it also cost nearly as much —about $2.00 a gallon. Other substitutes were lard oil (dim flame, and cost of well over $1.00 a gallon) and rosin oil, cheapest of the lot at 50¢, with disadvantages in proportion.

There was room, obviously, for successors to these substitutes, and many who left scant records of their attempts brought forth for limited sale oils which they hoped would be cheaper, brighter, or less dangerous to use. A chief obstacle to most of these would-be innovators was that they were "practical" men with no knowledge of chemistry, a bad handicap, since all of these "artificial" oils had to be "rectified" or "refined" chemically in order to remove impurities which caused bad burning and foul odors. When at last successful substitutes did appear in the years just before the Civil War, they were the work of trained chemists.

Of first importance in the establishment of the new "coal oil" business which was flourishing so prosperously by 1859 was Dr. Abraham Gesner, Canadian physician and geologist. To Gesner belongs the credit for evolving and patenting a process for making illuminating oil out of bituminous rock, for launching its successful manufacture, and for thinking up the name "kerosene." Son of American Royalists who had removed to Nova Scotia during the Revolutionary War, Gesner had practiced as a physician in his native province, served as provincial geologist for New Brunswick, and had written several books, mostly on geology. As early as the summer of 1846, he demonstrated at public lectures on Prince Edward Island an illuminating oil he had distilled from asphalt from the Great Pitch Lake of Trinidad. In 1849, Gesner discovered a vein of bituminous rock called "Albert coal," or albertite, in Albert County, New Brunswick, and promptly turned his hand to this nearby material, making a satisfactory lamp oil from it.

During these same years, he became acquainted with Thomas Cochrane, 10th Earl of Dundonald, then stationed at Halifax as British Admiral for North America. Dundonald's father, the 9th earl, "an ingenious but most unfortunate inventor," had been years ahead of his time with a British patent of 1781 for extracting coke, tar, oil, and naphtha from deposits of bituminous rock in Scotland. His son, a lifelong naval officer, had inherited his father's scientific bent and had himself taken out several British patents for making asphalt paving, waterproofing, roofing, and electrical insulation out of Trinidad bitumen; he had, moreover, assured himself of the right to exploit the Great Pitch Lake by buying up the land around it.

In the spring of 1853, Gesner, then in his 56th year, moved his family to New York; applied for American patents on his kerosene process; and set about enlisting capital to organize a company. An 8-page prospectus issued at New York in March 1853 proposed a joint-stock company of $100,000 capital to manufacture a complete range of products, from kerosene to asphalt, under the combined Gesner and Dundonald patents. The raw material would be the newly discovered Albert County mineral; some of the anticipated products were kerosene illuminating oil, naphtha for use in paint and rubber manufacture, railway grease, "mineral pitch" for varnish, "hydraulic concrete" for waterproofing and paving, paraffin for candles, coke and gas for burning

Plant typical of many which made camphene and "burning fluid" about 1845-60.

The Angle Lamp

is not an improvement on the old-style lamp, but an entirely new method of burning oil which has made common kerosene (or coal oil) the most satisfactory of all illuminants.

And when we say **satisfactory** we mean satisfactory—not an illuminant that merely gives a brilliant light but one that combines brilliancy, with soft, restful, **pleasing quality**; that is as convenient as gas, safe as a tallow candle, and yet so economical to **burn that in a few months' use**

It Actually Pays for Itself

For where the ordinary lamp with the round wick, **generally considered the cheapest** of all lighting methods, burns but about 5 hours on a quart of oil **The Angle Lamp burns a full 16 hours** on the same quantity. This, even where oil is cheap, soon amounts to more than its entire original cost. But in another way it saves as much—perhaps more.

Ordinary lamps must **always** be turned at full height, although on an **average of two hours** a night all that is really needed is a dim light ready to be turned up full **when wanted. A gallon of oil a week absolutely wasted,** simply because your lamps cannot be turned low without unbearable odor. All this is saved in The Angle Lamp, for whether burned at **full height** or turned low it gives not the slightest trace of odor or smoke.

You should know more about the lamp which for its convenience and soft, restful light might be considered a luxury were it not for the wonderful economy which makes it an actual necessity. Write for our catalogue "31" fully explaining this new principle of oil lighting and for our proposition to prove these statements by

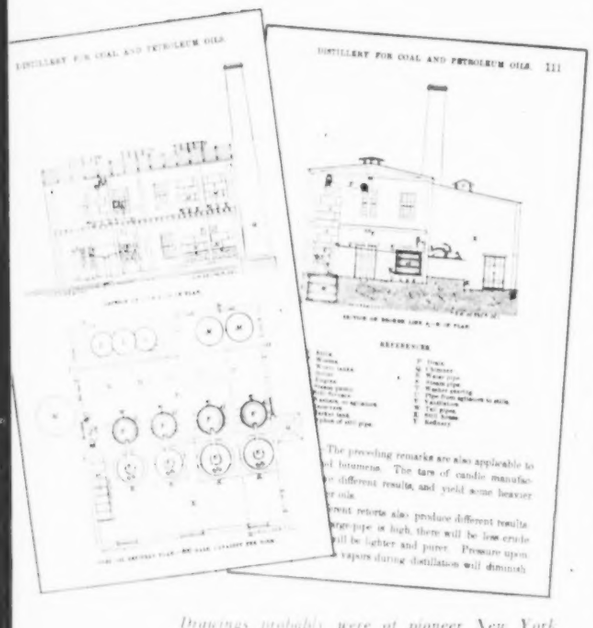
30 Days' Trial

When such people as ex-President Cleveland, the Rockefellers, Carnegies, and thousands of others, after trying The Angle Lamp, find it profitable to rip out gas and electric-light fixtures, to throw away gasoline and acetylene outfits or ordinary lamps, it is surely worth your while to send a penny postal to find out about it.

Our catalogue "31" which lists 32 varieties from $1.50 up, and gives you the benefit of our experience with all kinds of lighting methods

THE ANGLE MFG. COMPANY, **78-80 Murray St., N. Y.**

Kerosene angle lamp at close of kerosene age about 1901 (photo by Culver Services, New York).



Drawings probably were of pioneer New York Kerosene Co. works designed by Dr. Gesner in 1854.

"in the manufactory," and the ammonia-containing ash for fertilizer. Counting only the anticipated receipts from illuminating oils and asphalt, the prospectus said, a ton of Albert mineral costing $5.00 could be made to yield products worth $43 after manufacture.

This proposed company materialized early in 1854, when a group of New York businessmen organized the North American Kerosene Gas Light Co. and purchased a 7-acre plant site on Newtown Creek, Queens, near Calvary Cemetery. Shortly afterward, in June 1854, Dr. Gesner's patents issued from the patent office, assigned to the new company. Gesner was apparently given stock in exchange for his patents; Dundonald, then nearly 80, dropped out of the picture at this point.

Gesner's patents were three in number, one for each of three kerosenes (kerosene "A," "B," and "C"), to be manufactured from "petroleum, maltha, or soft mineral pitch, asphaltum, or bitumen wherever found."

The raw material, as set forth in Gesner's patents, was subjected to destructive distillation in an iron retort, the vapor being led away and condensed in pipes immersed in water. The products left in the retort, a heavy tarry liquid and a lighter liquid, were then separated by drawing off the heavier fraction. The remaining lighter liquid was redistilled, the distillate from it being condensed and mixed with the first distillate, and the residuum drawn off and mixed with the heavy bottoms of the first distillation. The light liquid distillate was next treated by agitating it with a 5% to 10% solution of sulfuric acid, and allowed to stand 12 to 24 hours to permit the impurities to settle out. The distillate was then drawn off and mixed with 2% by weight of freshly calcined lime, which accomplished the dual purpose of absorbing any water present and neutralizing the effect of the sulfuric-acid treatment. After thorough agitation, the treated product was fractionally distilled into kerosene "A" (boiling point 150 F, specific gravity, 0.750); kerosene "B" (bp 250 F; 0.775 sg), and kerosene "C," with a boiling point of 350 F and specific gravity of 0.800. All three of these fractions fall within what is today considered the gasoline cut. The "A" fraction, too volatile to be safe in lamps, could be burned by vaporizing it with a current of air and burning the resultant gas in gas jets. The "B" kerosene, "moderately volatile and inflammable," could be burned in a lamp, or mixed with the third cut. It was the "C" kerosene which offered most promise as an illuminator: "in an Argand lamp, with a button over the wick, it burns with a brilliant white light."

In addition to claiming the products and the processes by which they were distilled and treated, Dr. Gesner's patents included the trade name he had adopted, "Kerosene." A son, who was present at the christening of the new product, tells us that the name came from the Greek word *keros*, wax, and the *-ene* ending of camphene, in the expectation that this ending would suggest a burning oil. For the next decade, Kerosene (with a capital "K") was a protected trade name like "Victrola" or "Frigidaire," but it soon passed into the common language. It was often misspelled *kerosine*, an error which has unfortunately been perpetuated by well intentioned oil-industry groups attempting to adopt "official" spellings.

Following the custom of the day, the new Kerosene Works appointed sales agents, John H. and George W. Austen, sons of a prominent New York merchant. The Austens opened sales offices at 50 Beaver Street, New York, and began a vigorous campaign to introduce the new illuminant, along with a suitable lamp for burning it. Kerosene burned well in the expensive Argand lamp used for sperm oil; but John Austen sought, and in Vienna found, a cheap flat-wick metal lamp with glass chimney. This lamp the Austens imported in quantity and the "Vienna burner," widely copied, became the model for the common kerosene lamp.* A new kerosene customer generally bought a complete outfit with his first purchase. (See bill of sale illustrated).

"The new illuminating oil," Dr. Gesner's son wrote some years later, "met with the strongest opposition from the turpentine and alcohol trades. Its odor, which was not then so well removed as it was later on, gave those interested a weapon against its introduction which at times seemed likely to be wielded fatally." However, the relative safety, superior light, and low price of the new product gave its manufacturers sales arguments which were hard to put down. A circular issued by the Austens early in 1856 is replete with "laboratory tests" comparing the illuminants then on the market. In intensity of light, kerosene won hands down. Kerosene was then selling for $1.00 a gallon, as against $2.25 for sperm oil, $1.50 for colza oil, $1.25 for lard oil. Burning fluid, at 87¢ a gallon, was cheaper, as were camphene (63¢) and rosin oil (50¢). But the brilliance of kerosene light and its consumption economy gave it impressive advantages when reduced to "cost of an equal amount of light." On this basis, burning fluid was seven times as expensive; sperm oil cost six times as much, and so on down the scale.

As kerosene's acceptance spread, the size of the Kerosene Works on Newtown Creek expanded. A lengthly description of the bustling plant was printed in the New York *Commercial Advertiser* on August 24, 1859, just three days before completion of the

* From fragmentary evidence like this, oil historians have long suspected that at an early date crude oil was produced and refined for illuminating purposes in the old Austro-Hungarian Empire. In a new book dedicated to the Fifth World Petroleum Congress, *More Studies in Early Petroleum History*, by Prof. R. J. Forbes, of Amsterdam, we have at last the first substantial account in English of the beginnings of the Galician oil industry at Lwow (Lemberg) in what was once southern Poland, in 1852. The Lemberg hospital installed kerosene lighting in 1853, the Northern Railway terminated at Vienna, in 1854. Romanian refining had started as early as 1840.

Drake well at Titusville. Output was then running at the rate of 5,000 gallons a day; several new factory buildings were then in process of construction; raw material (by now Boghead coal from Scotland) was being imported at the rate of 30,000 tons a year; the plant was valued at $1,250,000, had its own cooperage, employed 200 regular hands, and had another 25 men who "find constant employment in erecting buildings and putting up machinery." Kerosene was bringing $1.15 a gallon at the refinery; a report Dr. Gesner made for the company at the time showed that the company's costs were 63¢ a gallon. With such handsome profits to be made, it is no wonder that formidable competitors were appearing on the scene—although the Kerosene Works on Newtown Creek remained the largest.

Two competitors of interest and importance were the plants of James Young at Bathgate, Scotland, and of Samuel Downer, Jr., at South Boston, Mass. Both of these coal-oil enterprises had initially been concerned with the manufacture of "artificial" lubricating oils which would give better service than the animal and vegetable lubricants then on the market. By the mid-1800's, the rapidly growing railways and the introduction of high-speed steam-powered textile and printing machinery had created an urgent demand for lubricating oils which would not break down under the heat generated by high-speed operation. In the years between 1845 and 1860, many eager inventors took note of this profitable new demand and hurried to the patent offices.

Young, who deservedly gets the credit for establishing the Scotch shale-oil industry, is frequently credited with the manufacture of the first coal-oil illuminants as well. While he cannot be accorded the honor which properly belongs to Gesner, Young's technical achievements were, nevertheless, of first magnitude. He also had the advantage of having preceded Gesner to the patent office.

Young, a Glasgow-born college-trained chemist, was manager of alkali works at Manchester when, late in 1847, the owner of a coal mine in Derbyshire, England, approached him with a problem. James Oakes, the mine owner, reported the discovery of a small petroleum spring in his "New Deeps" mine at Riddings. The petroleum, because of its flammable nature, was a nuisance to dispose of; could Young make anything useful out of it? It was a thick, almost black crude oil. After some experimentation, Young reported that lubricating oils and paraffin for candles could be made from it.

In the fall of 1848, Oakes and Young signed a partnership arrangement, providing that Oakes would furnish crude oil and a plant to refine it; Young would be responsible for the manufacture and sale of products. The crude-oil production from the mine was small—only about 300 gallons a day—and Young soon found himself facing the necessity of increasing the supply if he was to operate a profitable business. Reasoning (albeit incorrectly) that the crude petroleum found in the mine had been generated from coal by the action of subterranean heat, "I started an investigation," Young later wrote, "with the prospect of procuring petroleum, or a substance equivalent to it, from coal and after some time succeeded . . . The process consists in the distillation of coal at the lowest possible temperature at which it can be decomposed. By this process we obtain a mixture of several liquids with paraffin dissolved in them. This liquid I named paraffin oil." His methods of distilling bituminous coal for its paraffin content, treating the extract, and purifying the solid paraffin wax were described in a British patent issued to Young in October 1850 and in a USA patent of March 1852.

Young canceled his manufacturing contract with the mine owner and in 1850-51 moved to Bathgate, West Lothian, Scotland, where he erected a new plant to work the nearby cannel-coal deposits, called variously Boghead coal, Torbane Hill mineral, or torbanite. He had as partners in this venture Edward Meldrum, a chemist formerly in his employ, and E. W. Binney, a Manchester lawyer. This new plant, Young tells us, "at first manufactured naphtha and lubricating oil. Paraffin oil for burning and solid paraffin were not sold until 1856, and the demand for it only became considerable in 1859."

This account ties in well with the recollections of Joshua Merrill, for many years superintendent of the Downer Works at South Boston, Mass. Samuel Downer, Jr., had been a prosperous Boston whale-oil merchant and manufacturer of sperm candles since 1834. Looking for lubricating oil which would have better performance characteristics in high-speed machinery, Downer about 1854 acquired a strugggling firm at Waltham called the United States Chemical Manufacturing Co. This company, organized by Dr. Samuel R. Philbrick and the brothers Luther and William Atwood, manufacturing chemists of Boston, was attempting to make and market a patent lubricating oil distilled from byproduct coal tar. Although Dr. Philbrick and the Atwoods were competent technical men, they were having great difficulty in overcoming the odor of their coal-tar lubricating oil. Merrill, their salesman, reported that 90% of their customers could not be induced to place a second order. Downer appeared to be on the verge of losing his investment when, in 1855, a letter arrived from Scotland which completely changed the course of events.

George Miller & Co., of Glasgow, had heard of the process to distill lubricating oil from coal tar and wished to install it. Downer promptly dispatched Luther Atwood, the best chemist of the three, to Scotland, and there he remained a year, building and installing the manufacturing apparatus. The Miller concern was a large manufacturer of coal-tar naphtha, a product then very much in demand for use as a rubber solvent in the manufacture of mackintosh rubber goods for the Crimean War. To supplement their own production, the Miller people bought naphtha from other manufacturers, including Young's works at Bathgate. Atwood, an inveterate experimenter, took some of the naphtha which Miller was buying from Young for sixpence per gallon and by a little treatment made it into a water-white illuminating oil.

Some of this oil was burning in a lamp in the Miller offices one day in 1856 when Young happened in. Miller told him, "That is some of your brown Bathgate naphtha that our chemist has been manipulating and refining and there is a sample of the oil." Young took the sample, was impressed with its possibilities as an illuminant, and promptly began manufacture of lamp oil—shipping most of his initial production to Austria, where hydrocarbon illuminating oils and lamps to burn them were already in use. Before long, Young's new illuminant would also be a standard item of commerce in the British Isles, under the name "paraffin oil."

In October 1856, shortly after the incident in the Miller & Co. office in Glasgow, Luther Atwood and Joshua Merrill (who had also been in Scotland for some months) returned home, bringing with them a sample of the lamp oil Atwood had made. Both men were excited about the possibilities of manufacturing a similar lamp oil in Boston, using raw materials closer to hand. While they had been away, William Atwood, working under Downer's direction, had erected a retort on Downer's South Boston property to distill Trinidad bitumen from the Great Pitch Lake, with the object of making lubricating oil. Against Downer's better judgment (after all, he was still in the whale-oil business and had just poured $100,000 into facilities to make lubricants from coal tar), the Atwoods and Merrill set about producing a lamp oil from the Trinidad asphalt. It was sold on a small scale to two Boston lamp merchants, Knapp and Jones, and this initial success stimulated a search for other raw materials. During 1857, they switched to Albert coal, then being brought to Boston by the city gas works for use in gas enrichment. It proved so satisfactory that Downer contracted to

Samuel Downer

Prof. Benjamin Silliman, Jr.

buy it direct from the mine at $25 a ton delivered, taking some 7,500 tons the first year.

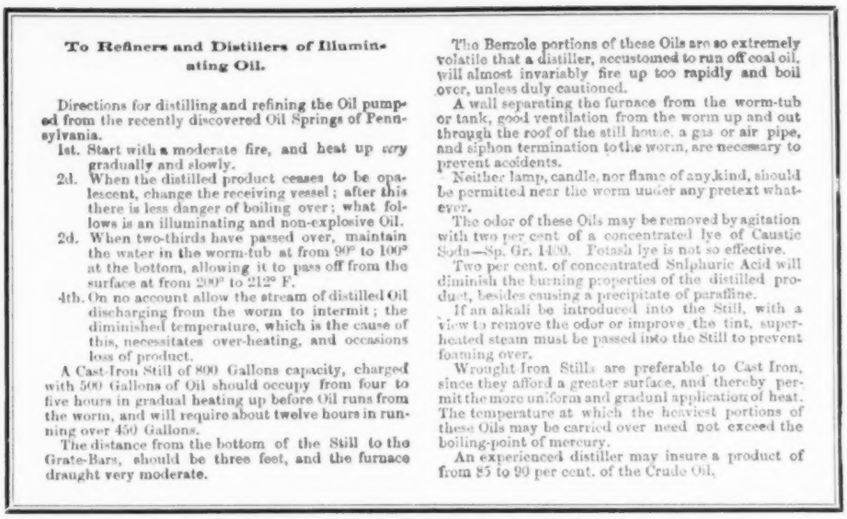
Downer's reluctance to enter the new coal-oil business was now completely overcome. Early in 1857, he sold his whale-oil business to two former employees and began building coal-oil facilities with a will. By the fall of 1858, he had invested $150,000 in the new plant, had 50 retorts operating 24 hours a day, and had accumulated an unsold inventory of 200,000 gallons of lamp oil. Just as Downer was beginning to doubt the wisdom of his bold course, the product caught on. Orders came pouring in all during the fall and winter of 1858-59, until the Downer warehouse bulged with dealers' empty tins, dated and ticketed to be filled in order of receipt. With demand so brisk and the oil bringing $1.35 to $1.40 a gallon at the refinery, the Downer Works made a net profit of more than $100,000 during the winter of 1858-59. It was a turning point for the new venture and, in Merrill's words, "Mr. Downer was in great courage and hope at result." Promptly, he built a second manufacturing plant at Portland, Me., putting Dr. Philbrick and William Atwood in charge.

Meanwhile, Luther Atwood had become chief chemist of the Kerosene Works on Newtown Creek. Through this friendly connection, Downer was able to license the right to use the protected trade name "Kerosene," and by early 1859 all three plants had changed their names—the New York Kerosene Oil Co., Boston Kerosene Oil Co. (Samuel Downer, Prop.), Portland Kerosene Oil Co.—and were publishing warning circulars to establish their exclusive right to the Kerosene name.

As protection of his refining process. Dr. Gesner's kerosene patents were not so successful. Young, with his British patent of 1850 and USA patent of 1852, had precedence over Gesner's 1854 patents. Young had a keen sense of the value of patents and, by threat of infringement suits, obliged his American competitors to take out licenses under his patent and pay him a royalty of a penny a gallon sterling (2 cents, American money). By 1858, twenty-three American coal-oil refiners, including the original Kerosene Works on Newtown Creek, were licensees under the Young patents.

The largest of these coal-oil refineries by 1859 were, in order, the Kerosene Works in New York and Downer's plants in South Boston and Portland. By this time, the New York Kerosene Works was using Boghead coal from Scotland as raw material, as did some of their smaller competitors in the New York area. Other plants along the seaboard, including Downer's, used Albert coal from New Brunswick. The refineries in the western regions—at Pittsburgh, along the Kanawha River of West Virginia, and on both the Kentucky and Ohio banks of the Ohio River—were all located so as to take advantage of nearby deposits of cannel coal.

Dr. Gesner and his sons, pursuing careers as consulting chemists to the burgeoning coal-oil industry, did a lively business in the design and construction of refineries to work the western cannel-coal deposits. "Country ministers," one of the Gesner sons recalled years later, "could not be persuaded that anything could be distilled from coal, and insisted that coal distillation was a cloak for another kind, much more to the taste of their flocks."



To Refiners and Distillers of Illuminating Oil.

Directions for distilling and refining the Oil pumped from the recently discovered Oil Springs of Pennsylvania.

1st. Start with a moderate fire, and heat up *very* gradually and slowly.

2d. When the distilled product ceases to be opalescent, change the receiving vessel; after this there is less danger of boiling over; what follows is an illuminating and non-explosive Oil.

3d. When two-thirds have passed over, maintain the water in the worm-tub at from 90° to 100° at the bottom, allowing it to pass off from the surface at from 200° to 212° F.

4th. On no account allow the stream of distilled Oil discharging from the worm to intermit; the diminished temperature, which is the cause of this, necessitates over-heating, and occasions loss of product.

A Cast-Iron Still of 800 Gallons capacity, charged with 500 Gallons of Oil should occupy from four to five hours in gradual heating up before Oil runs from the worm, and will require about twelve hours in running over 450 Gallons.

The distance from the bottom of the Still to the Grate-Bars, should be three feet, and the furnace draught very moderate.

The Benzole portions of these Oils are so extremely volatile that a distiller, accustomed to run off coal oil, will almost invariably fire up too rapidly and boil over, unless duly cautioned.

A wall separating the furnace from the worm-tub or tank, good ventilation from the worm up and out through the roof of the still house, a gas or air pipe, and siphon termination to the worm, are necessary to prevent accidents.

Neither lamp, candle, nor flame of any kind, should be permitted near the worm under any pretext whatever.

The odor of these Oils may be removed by agitation with two per cent of a concentrated lye of Caustic Soda—Sp. Gr. 1400. Potash lye is not so effective.

Two per cent. of concentrated Sulphuric Acid will diminish the burning properties of the distilled product, besides causing a precipitate of paraffine.

If an alkali be introduced into the Still, with a view to remove the odor or improve the tint, superheated steam must be passed into the Still to prevent foaming over.

Wrought Iron Stills are preferable to Cast Iron, since they afford a greater surface, and thereby permit the more uniform and gradual application of heat. The temperature at which the heaviest portions of these Oils may be carried over need not exceed the boiling-point of mercury.

An experienced distiller may insure a product of from 85 to 90 per cent. of the Crude Oil.

Circular sent to coal-oil refiners by Schiefflin Bros. in 1860 to demonstrate simplicity of refining petroleum.

Samual Kier, son of a salt-well owner of Tarentum, Pa., had since 1849 been recovering petroleum, an accidental and unwanted byproduct of one of his father's salt wells, bottling it and selling it as medicine. About 1855, he set up a one-barrel still and began distilling some of his petroleum production as lamp oil. Since he did not treat it to remove impurities, it smoked badly when burned and gave off foul odors. Even so, it had a mild local sale in the Pittsburgh area, and Kier had graduated to a five-barrel still by the fall of 1857 when his "carbon oil" came to the attention of Colonel A. C. Ferris, a lamp-oil merchant of New York. Finding Kier's untreated oil unsaleable, Ferris hired a man who had learned acid-soda treating methods at Downer's Portland works, and sent him to Pittsburgh to instruct Kier. The resulting product was marketed on a small scale beginning in 1858 by Ferris' New York Carbon Oil Co. Ferris also purchased, for refining, crude oil from the hand-dug petroleum wells of southwestern Ontario, as well as shale oil from France. While the Kier-Ferris effort is of interest for its pioneering aspects, its importance as a successful commerical enterprise has often been exaggerated by oil historians, and it is mentioned here chiefly for the purpose of putting it in proper perspective. By late 1859, the Carbon Oil Works was producing only 300 gallons a day—a small amount compared to the output of the large, well financed coal-oil refineries.

But petroleum refineries would not remain small much longer. When Drake's oil well came in in August 1859, there was an immediate appreciation of petroleum as raw material for lamp-oil manufacture. Others lost no time in acquiring leases and assembling equipment to begin drilling. Late in 1859, a second well was brought in. This, along with Drake's 8- to 10-barrel-a-day well and the oil gathered from salt wells, constituted the recorded crude-oil production of 1859—2,000 barrels at an average price of $20 a barrel, or 50¢ a gallon. This was hardly a price to tempt coal-oil manufacturers, for their own manufacturing costs for a gallon of kerosene were about the same. But when new and larger wells came in early in 1860, the economics of petroleum began to change rapidly.

The first book on the new Pennsylvania petroleum industry, published in June 1860, listed $16 a barrel, or 40¢ a gallon, as a typical price for crude oil, adding that "it can be raised, barreled and freighted to New York, for 12½ cents a gallon." This gave the producer a handsome profit and stimulated the rapid drilling of dozens of other wells. By the end of 1860, there were 75 wells along Oil Creek with a daily production of some 1,200 barrels, and crude sales as low as 22¢ a gallon ($8.80 a barrel) were being reported.

This rapid reduction of crude-oil price quickly brought new refineries onto the scene. Dr. Gesner, in his capacity as consulting chemist to coal-oil refiners, wrote and published an excellent handbook, *A Practical Treatise on Coal, Petroleum, and Other Disitlled Oils* (1861). When this volume went to press in November 1860, Gesner listed 56 coal-oil refineries by name

and added, "There are also fifteen establishments where petroleum only is worked." Most of them were small, homemade worm stills located near the oil fields, but already some of the coal-oil refineries had begun to buy and run petroleum.

Crude-oil production in 1859 and 1860 was a trickle compared to what was to come. During 1861, production from the oil fields of Pennsylvania, West Virginia, and Ohio came to 2,114,000 barrels, with the average price dropping to 52¢ a barrel, or 1.3¢ a gallon. New refineries sprang up by the dozen in the oil regions, and the older manufacturers of coal oil were faced with the choice of abandoning the business or converting to the new raw material. Petroleum, in addition to its initial cheapness, had the advantage of being far less expensive to refine. Its liquid state meant complete elimination of the costly retorts and high heat expenditure required for the destructive distillation of cannel coals and oil shales, the first step in coal-oil manufacture. All that was necessary with petroleum were the subsequent steps of fractional distillation and acid-soda treatment.

The original Kerosene Works on Newtown Creek in 1861 made careful calculations, concluded they could afford to distill coal only when crude oil was above $14 a barrel, and switched to the new petroleum.

Samuel Downer, Jr., who seems to have been ever ready to pay the price of technological progress, canvassed the oil regions for a suitable site for a new refinery. Assisted by the versatile Atwood brothers and Joshua Merrill, he spent $125,000 to build a large petroleum refinery at Corry, Pa., late in 1861. Crude oil was shipped to the Downer Works in Boston, which gradually became a lubricants plant. Downer's Portland Kerosene Works, farthest from the oil fields and nearest to the New Brunswick albertite mines, became in 1865 the last of the coal-oil works to convert to petroleum.

Many of the coal-oil plants located along the seaboard successfully converted to petroleum. But most of the back-country plants, which had been built to be near cannel-coal deposits, found themselves inconveniently located for receiving crude oil or shipping finished products and quietly folded up. An exception was the business of Eugene R. Grasselli of Cincinnati, who had during the late 1850's operated a successful coal-oil works at Newport, Ky. Finding his conversion to petroleum unprofitable because of location, Grasselli reverted to the manufacture of one of his plant's chief raw materials, sulfuric acid, eventually evolving the Grasselli Chemical Co., which was one of the nation's largest producers of heavy chemicals when it was purchased by DuPont in 1928.

Another 1861 conversion to petroleum was that of Stephen Jenney & Co., of Boston. The Jenneys had started out as whale-oil merchants in 1812. In 1856, observing the decline of their original business, they had built an alcohol and camphene plant in South Boston and begun the manufacture and sale of "burning fluid." In 1861, this plant was converted into a petroleum refinery and manufactured petroleum products for local sale and export until World War I, when it was gradually converted into a compounding plant and depot. The company, organized in 1884 into a family corporation under the name Jenney Manufacturing Co., continues to flourish as a leading Massachusetts marketer of oil products under the presidency of a fifth-generation Jenney—a happy refutation of notions about the peculiar vulnerability of oil-marketing companies and family businesses. During its 147 years of history, the Jenney company has participated successively in the whale-oil, camphene, kerosene, and gasoline business, and enjoys the distinction of being the world's oldest oil enterprise.

James Young, pioneer of the Scotch shale-oil industry, visited America in 1860 and took a trip through the new oil regions. Remembering his own early experience with a petroleum "spring," he took a dim view of the Pennsylvania developments. "I dinna think it will amount to mooch," he told Joshua Merrill of the Downer Works, "it is ephemeral and won't last. We had a lot of petroleum in England, when I first began, from the Derbyshire mines. The first oil I ever made was from petroleum, but it proved to be in pockets and very limited in quantity." When his deposits of Boghead coal ran out, Young turned to the oil shales of West Calder, erecting a large new plant there. His patents expired in 1864. Two years later, he sold his business for $2,225,000 to a newly organized joint-stock company, Young's Paraffin Light and Mineral Oil Co. Ltd., in which he retained a quarter interest. Despite hard competition from the American petroleum business, the Scotch shale-oil industry perservered by dint of economical management and careful exploitation of byproducts such as ammonium sulfate and paraffin wax. Young's company still exists as one of the Scotch shale-oil firms today owned by the British Petroleum Co. Ltd. As Gesner's name "kerosene" became synonymous with lamp oil on this side of the Atlantic, so did Young's term "paraffin" come to denote the same product in the United Kingdom.

Young died in 1883; Downer, in 1881. The Downer Works, which had prospered and become famous as the first large-scale exporter of American kerosene, passed into the hands of the growing Standard Oil Co., and were eventually dismantled—the Boston and Portland properties long thereafter serving as depots. Luther Atwood, who held cracking patents, and Joshua Merrill, who had a lubricating-oil process, were rewarded by sale of their patents.

The Kerosene Works on Newtown Creek was purchased in 1876 by Chas. Pratt & Co., a subsidiary of the old Standard Oil Co. of New York, and operated as Socony's Queens Works until May 1952.

Dr. Gesner, like Drake, failed to profit much from his pioneering work, for both were salaried employees with only nominal ownership in the enterprises they helped start. In 1863, Gesner, then 65, returned to his native Nova Scotia to become a professor at Dalhousie University, but died early in 1864 before he could take up his duties. The book he brought out in 1861 was issued in revised edition by his son, G. W. Gesner, in 1865 to become a standard text of the early refining industry, and his memory is recalled daily by thousands of people the world over when ever they mention "kerosene."

So much, then, for the story of the early refineries which were, in Gesner's own words, "the labors not of one mind, but of many, so as to render it difficult to discover to whom the greatest credit is due." The whale-oil business, whose high costs and high prices had been the indirect cause of it all, passed from the American scene, leaving behind romantic memories preserved in a handful of new England whaling museums and the oil industry's standard measure, the old 42-gallon whale-oil barrel.

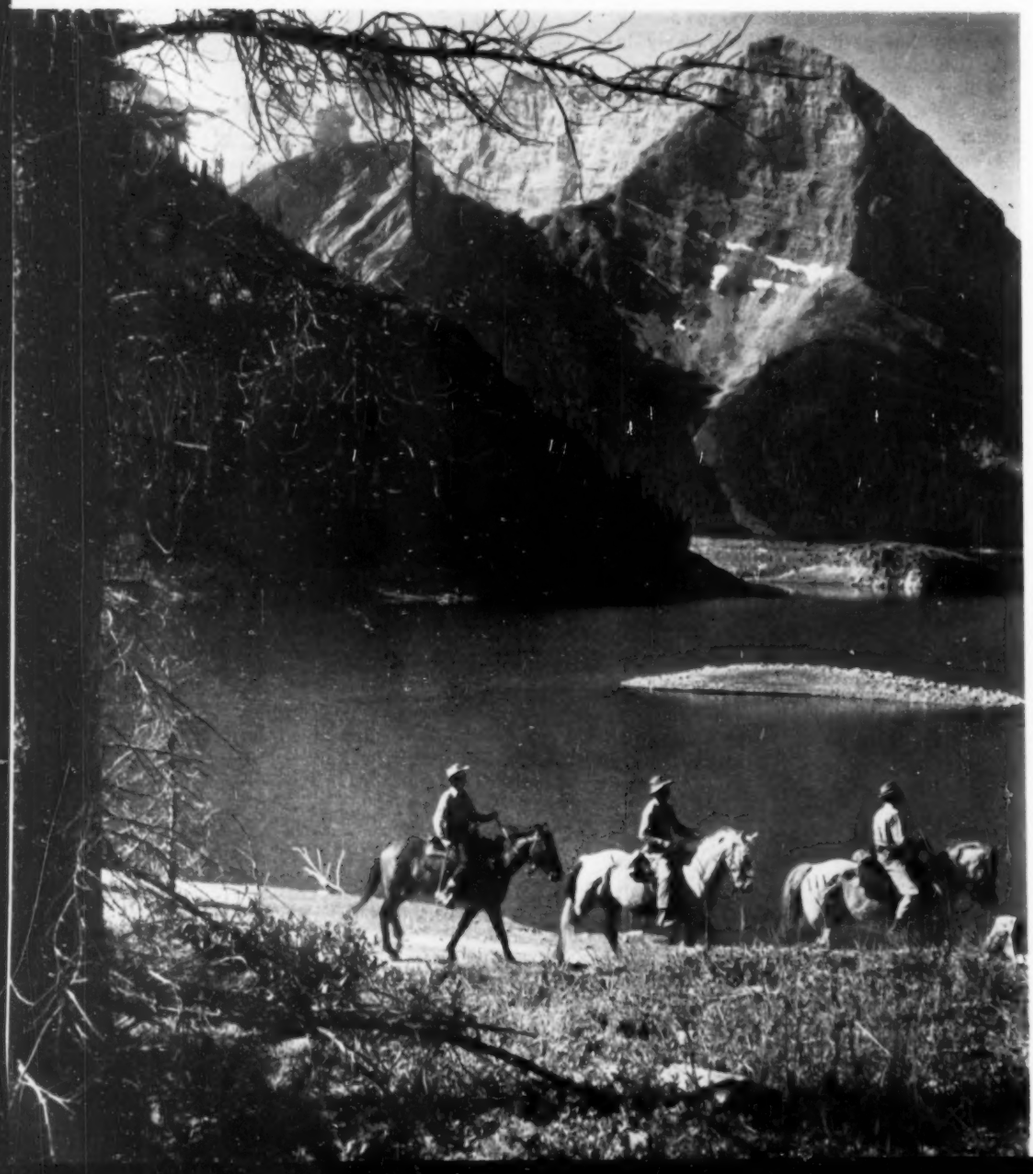
On the threshold of petroleum's second century, it is instructive to recall these accomplishments which led to its first hundred years. And it is tempting to speculate for the unseeable years ahead: Who will be the new innovators, the Gesners and the Youngs? Who, like Downer, the welcomers of costly technological change? And who, like the Jenneys, survivors a hundred years hence? END

Lighting of homes by kerosene in the '90's (photo by Brown Bros., New York).

WILLIAM MATHEWS VACY ASH, president of Shell Oil Co. of Canada Ltd., Toronto, was born in Scotland in 1907. He was educated at Glenalmond, Scotland; Grenoble University, France; and Oxford University—the latter having conferred upon him an M.A. degree in law. Formerly he had been assistant to the vice president in charge of production, Shell Oil Co., Los Angeles; executive assistant to the president of Shell Oil Co., New York; general manager of Shell Exploration Alberta Ltd.; and general manager of United British Oilfields of Trinidad. He also has been president of the Petroleum Assn. of Trinidad; member of the Trinidad Legislative Council; and past chairman, Canadian Highway Safety Conference.

Canada's bright future

by W. M. V. Ash, President, Shell Oil Co. of Canada Ltd.



Geological party in the Canadian Rockies.

THERE can be little doubt, and indeed it can be proved statistically, that energy consumption and economic growth go hand in hand. This does not necessarily mean that an abundance of energy resources results automatically in a high level of economic activity. The energy must be set to work intensively if the highest standards of living are to be attained. The development of the Canadian economy is a good example of the effectiveness of increased energy application. Today, with a work force a little more than double that at the beginning of the century, Canadians are producing more than six times as many goods and services. Improved equipment and advanced techniques have contributed greatly, but most significant has been the fivefold increase in energy use since 1900.

The postwar decade has been a period of remarkable growth for the Canadian economy, based upon natural-resource development, industrial diversification, high levels of capital investment, and increasing energy application. The petroleum industry has played a large part in all of these phases of development. By 1956, Canada was second only to the United States in per-capita energy consumption—and petroleum, by contributing 52% of all energy, was a more important form of energy in Canada than in any of the other countries listed in the accompanying table.

Energy Consumption—1956

	Total Energy Consumption (Btu's $\times 10^{12}$)	Per Capita (Btu's $\times 10^{6}$) Energy Consumption	Per-Capita Demand for Oil	% Petroleum Participation
USA	42,753	254	19.1	44
Canada	2,717	169	16.4	52
United Kingdom	7,786	152	4.5	17
West Germany	5,461	101	2.2	13
France	3,506	80	3.7	17
Italy	1,554	32	2.1	39

In 1946, petroleum supplied only 25% of Canada's energy needs, the large gain having been made at the expense of coal consumption.

Canadians were also the world's second consumers of petroleum on a per-capita basis in 1956. In that year, the Canadian average was 16.4 bbl per person, or 85% of the USA average of 19.1 bbl per person. Once again the postwar growth is remarkable—the 1946 Canadian average being 6.6 bbl per person, or only 52% of the USA annual consumption per person. This narrowing gap reflects the fact that, in this period the use of oil increased almost three times as rapidly in Canada as in the United States. The primary importance of oil to the North American economy is evidenced by the wide spread between the Canadian average consumption in 1956—16.4 bbl—and that in the United Kingdom, the third largest per-capita user—4.5 bbl.

Canada has long been known as a repositary of virtually all minerals known to man—and the full extent of this mineral wealth has still to be charted, as the great frontier to the North continues to challenge us. The value of mineral production increased to $2,134 million in 1957 from $503 million in 1946, as most of our known mineral deposits were subjected to intensive development in response to both domestic and worldwide demands. In this setting, it is even more gratifying to see oil's share of total mineral production increase to 21% in 1957 from 3% in 1946, and to note that, since 1953, oil has been Canada's most valuable mineral in terms of annual production.

All economic development, including national-resource utilization, requires capital outlays—and here again the Canadian record has been noteworthy. In 1946, capital expenditures by business and government were 14.2% of gross national production. The next 10 years saw a steady increase in the rate of expenditures; and, by 1957, Canadians were reinvesting 28.3% of annual production, and the average for the period was 22%. The oil industry contributed in substantial measure to overall development. Before the 1947 Leduc discovery, capital expenditures by oil companies in Canada accounted for less than 2% of all industry, while this share has averaged 10% since 1953.

The Prairie Provinces: The postwar development of the oil industry has naturally had its profoundest impact on the producing provinces. Before the historic Leduc discovery early in 1947, Alberta exemplified the difficulties of the Prairie Provinces, beset in the prewar years by the problems of poor harvests, low crop prices, and dwindling population. There was some hope that the postwar reconstruction programs would help to revive the economy, although realists could not see this assuming large proportions. Then suddenly—almost overnight—a new impetus was found in the rush to develop the petroleum potential which the Leduc find promised. Over the next 10 years, billions of dollars poured into the province, generating billions more in secondary expenditures. Population began a rapid increase, personal income rose, the towns and villages spread out over the prairie, and Albertans enjoyed a decade of prosperity unequaled in their history. The rising tide of these years spilled over into the other Prairie Provinces, as the oil search spread eastward into Saskatchewan and Manitoba. Alberta, which only 10 years ago derived 80% of all personal income from agriculture, is now becoming a region of diversified activity, with secondary and tertiary industries developing rapidly. The Alberta economy has weathered these boom years, and is now settling down to a future of more conservative development on the broad base of its new-found mineral wealth.

Between 1947 and 1956, the oil industry invested $2.4 billion in Alberta. Most of these funds originated outside the province, and the far-reaching effects of their distribution radically altered the provincial profile. Exploration and development activity accounted for $1.9 billion, and only in 1953 did these expenditures fail to show an annual increase over the preceding year. When allowance is made for the origin of these funds, the final effective destination of expenditures, and the secondary income effects, it has been estimated that total income generated within the province was approximately $2.4 billion.

Before World War II, Alberta had been losing population as net emigration exceeded the natural increase. This problem was shared by the other Prairie Provinces. It was symptomatic of the depressed '30's, and more particularly the stagnant levels of agricultural incomes. Between 1946 and 1956, Alberta's population increased to 1,123,000 from 803,000. This 40% gain exceeded that of any other province. It compares with the Canadian increase over the same period of 27%. There seems little doubt that, without oil and related developments, the prairie population would have declined over the postwar decade; and it has been estimated that, in 1956, more than half a million prairie residents could be related to oil developments—17% of total population.

It is impossible to assess with accuracy the employment induced in other industries due to the far-reaching effects of successive rounds of secondary spending. The most important change was the decline in the relative importance of agriculture to the provincial economy. In 1946, 41.3% of the labor force was employed in agriculture; and, 10 years later, the percentage had declined to 26.8%. The increased diversification of the area is shown by the greater importance of manufacturing, trade, and services. The declining dependence upon agriculture is further illustrated by the percentage of urban population which rose from 44.1% in 1946 to 56.6% ten years later. The twin cities, Edmonton and Calgary, between them attracted 70% of the total population increase over this period.

The Future: The future of Canada's oil industry might perhaps be epitomized in two broad propositions. Demand for petroleum products will go on increasing, although at a more modest pace than that experienced during the past 10 years—and Canadian crude production will supply a greater part of total demand. The average annual increase in demand for petroleum products in Canada since the war has been about 11%. Long distance, extreme climate, mechanized farming, high living standards, and rapidly expanding population have been the principal factors underlying this vigorous growth. The number of oil-heated homes increased fourfold, and motor-vehicle registrations 2½ times. It has been estimated that the growth trend will slow down to about 5% as saturation points are approached in motor-vehicle density and oil heating. The competitive force of natural gas in eastern Canada will also be a significant factor in retarding the rate of increase in the years ahead. Even so, total demand for petroleum in Canada should be about two million barrels per day by 1980. By that time, refinery runs should be 1.7 million barrels per day, of which 1.4 million will be from Canadian sources. The contribution of Canadian crude will increase as the refining complex in Ontario expands and acquires demands formerly satisfied from imported crudes.

The past successes of the Canadian petroleum industry have been achieved under the conditions of a market economy. This is not to say that the industry has been unregulated. But the provinces—in whom, under Canadian constitutional law, is vested the general jurisdiction over the minerals within their borders—have shown a judicious restraint in eschewing controls which hamper rather than encourage. Similarly, where federal jurisdiction has come into play—for instance, in extraprovincial movements of oil and gas—a willingness has been evidenced in the past to allow the same principles of a market economy to exert their natural influence. Oil men, who know their industry from the inside looking outwards, are agreed that it is this sort of climate which has nurtured the vigorous growth of Canadian development. Such men, "professionals" in their field, have no doubts of the industry's continued vigor, provided the temptation to "tinker" with it is resisted. 1958 was characterized by an investigation of the Canadian oil and gas industry by a royal commission as part of an inquiry into all forms of energy. Through detailed and voluminous testimony, the industry provided an impressive documentation of itself. Inevitably, problem areas have been disclosed—but, equally, areas of solid encouragement have also been shown to exist. Patching the gray areas, in effect by direct government action, has been advocated in some quarters. Most thinking oil men hope that government will avoid unnecessary intervention and avoid the creation, through rigid controls, of an artificial situation going contrary to natural economic laws. This only sets up a chain reaction of further controls which eventually extend into all phases of the business. END

OIL'S CONTRIBUTION TO THE BRITISH ECONOMY

by C. M. Vignoles

TODAY the British Isles, after the United States, the USSR, and Canada, constitutes the fourth largest market in the world for petroleum products, although it ranks only about 75th in area among the countries of the world. In population, however, the country ranks ninth, and there are 11 times as many people per square mile as in the United States. As a trading nation, Britain is second only to the United States, taking about a fifth of the world's exports of primary products, and in turn providing about a fifth of the world's exports of manufactured goods.

In the past 30 years, oil, as a proportion of total energy used, has grown from rather more than 4% to some 15%. Total energy consumed inland increased during the period by 70 million coal-equivalent tons, and of this increase oil has contributed nearly 27 million tons. Including the non-energy petroleum products such as bitumen, white spirit, lubricants, etc., inland consumption of oil increased to nearly 32 million tons last year from 5½ million. In addition, bunkers (excluding admiralty) increased to over four million tons from under one million tons.

Historically, the industrial prosperity of Britain has been based on coal, which is the country's main indigenous raw material. Helped by the proximity of plentiful iron ore alongside the coal deposits, Britain's older manufacturing industries have become situated on or near the coal fields. Britain is still the third biggest coal-producing country in the world, but during the past 30 years coal consumption has risen by only some 20%, while industrial production has expanded by 50%. It is in the past 10 years that industrial production has had its greatest increase—43%—and during this period oil consumption has more than doubled.

The British economy is highly industrialized, and only 6% of the working population is engaged in agriculture. In order to maintain her position as one of the leading trading nations of the world, it is important that production cost is kept as low as possible. Adequate supplies of cheap energy are, therefore, essential.

Supply of Oil: The rapid development of the oil industry in Britain in the past decade brought many problems of supply and distribution. There is very little indigenous production in the British Isles, and only about 2% of Britain's requirements of oil are home-produced, including the processing of oil from shale in Scotland. The country is thus almost entirely dependent on imports.

The principal source of supply is Kuwait, accounting for more than 48% of Britain's crude-oil imports. Other sources are Iraq (15%), other Middle Eastern countries (17%), Venezuela and the Netherlands West Indies (16%). Only 13% by value of Britain's oil requirements are now obtained from dollar areas.

Refining: In 1938, less than a quarter of Britain's consumption of petroleum products was home-refined. Since the end of the war, however, the pattern has completely changed. There has been very rapid expansion in the country's existing refinery capacity in the past few years. By 1950, half the country's consumption was refined here, and by 1952 the majority of the country's requirements were imported as crude and refined in Britain.

The establishment of refineries in Britain has made a valuable contribution to the increasing scope and variety of the country's economic development. In addition, in the vicinity of some of the major refineries, a fast-growing petroleum-based chemical industry has arisen.

The total investment in refineries to date is approaching £300 million; but, in order that refinery capacity may keep pace with estimated growth in consumption, the present capacity of some 35 million tons is to be increased to 47 million tons in the near future.

British refineries are, however, part of the western European pattern. While the greater part of the British refinery output is for consumption within the British Isles, the country is not self-sufficient in all products. Certain refined products continue to be imported, especially fuel oil from the Netherlands (over two million tons in 1958), while other products are exported, mainly to the Scandinavian countries. The value of exports last year reached £100 million.

A feature of consequence is the very different pattern of products demand in western Europe compared with the United States. In western Europe, demand for gasoline is about 20%, and for residual fuel oil 36%; whereas in the United States these proportions are 45% and 14%.

TABLE I
Western Europe and USA Main Product Requirements

	Western Europe %	USA %
Gasoline	20	45
Kerosines	4	4
Gas-diesel oils	23	23
Residual fuel	36	14

Distribution: The establishment and expansion of refineries in this country have largely determined the pattern of economical and efficient distribution and marketing. Before large-scale refining was firmly established, refined products had been imported at a variety of ports, and from these distributed to a large number of small installations and depots. Now, the import of

the crude to relatively few refineries enables distribution to be carried out far more efficiently.

Distribution from the refineries of Britain is based on the general principles—well understood in the oil industry—of handling products in as large volumes as possible, and reducing the number of intermediate stages to a minimum. It has been calculated, for example, that, for each intermediate step, the cost of delivery of motor spirit increases by about 20%.

Because of the very much lower cost per ton-mile of water-borne transport, installations, subinstallations, and depots have, wherever possible, been built either on the coast or on inland waterways. Other storage is fed either by road or rail. British oil companies are also pushing ahead with their plans for larger drops and larger vehicles. The maximum capacity permitted by law of road vehicles has been raised in the past few years to 4,000 gallons, and their gross laden weight to 24 tons.

Certain products, however, do not lend themselves readily to the application of the principle of big drops to the final consumer. The most difficult products are burning oil and vaporizing oil, and also lubricants, which have always been delivered in a large number of small lots. A remedy was found (in the case of one major oil company) in the creation of "authorized distributors." In a precisely defined geographical area, an authorized distributor takes over, on behalf of the oil company, the delivery of burning oil, as well as vaporizing oil, gas oil, and other products to the agricultural market. The company thus delivers these products in full loads into storage owned or rented by the authorized distributor, who in turn sells directly to farmers or householders.

As regards motor spirit, in furtherance of the same policy, service stations are urged to increase the size of their storage capacity by the installation of larger tanks, usually of 3,000-gallon size. Often these are provided by the oil companies on loan or hire-purchase terms. Partly on this account, the average size of drops to dealers has increased in the past year by more than 100 gallons to some 750 gallons.

It may well be asked why distribution by pipeline is so little used in the British Isles in contrast with the United States, where there are 150,000 miles of oil pipeline. The reason is that, with its long coastline, the abundance of inland waterways, and relatively short distances, the capital cost of laying down pipelines has rarely been justified. Nevertheless, in special cases short pipelines have been laid down, the most important of which is the 60-mile line between Finnart and Grangemouth refinery. Several new ones are also planned, 25 miles in the Manchester-Chester area, 60 miles from Milford Haven port to Llandarcy refinery, and a short one of 8 miles from Walton-on-Thames to London Airport to supply aviation fuels.

Pattern of Consumption: Both total consumption and the relative importance of the products have changed in recent years. For instance, whereas in 1938 motor spirit accounted for well over half the total inland trade of the British Isles of some nine million tons and gas-diesel and fuel oils less than one-sixth, last year, out of a total consumption (excluding refinery use) of nearly 30 million tons, gas-diesel and fuel oils accounted for almost one-half, with motor spirit less than one-quarter of the total.

C. M. VIGNOLES, CBE, president of the Institute of Petroleum (London), holds an honorary degree in mechanical sciences from Magdalene College, Cambridge. He has been managing director of Shell-Mex and BP Ltd. since 1951, after appointment as a director in 1950.

Mr. Vignoles joined the Shell group in 1924—with Asiatic Petroleum Co., in Malaya. He returned to London in 1932 to work in the fuel-oil department of Shell Petroleum Co.; in 1940 he became the company's representative on the Overseas Supply Committee of the Petroleum Board—later becoming the committee's joint executive secretary. Between 1945 and 1950, he was the Shell group's eastern area manager.

In November 1956, Mr. Vignoles became chairman of the Oil Industry Emergency Committee to assist the Minister of Power with oil-consumption problems arising from the Suez Canal crisis. For these services, he was awarded the CBE in June 1957; he had previously been awarded the OBE in 1946.

TABLE II
British Isles Inland Trade
(Excluding Refinery Consumption)

	(Thousands of Tons)			
Product	1928	1938	1948	1958
Motor spirit	2,788	5,019	4,411	6,060
Derv fuel*	—	392	830	2,100
Burning oil	741	607	599	1,190
Vaporizing oil		179	841	485
Gas-diesel oil	1,064	1,462	1,415	3,160
Fuel oil			2,861	10,835
Aviation fuels	—	200	395	1,630
Other products	958	1,394	1,525	3,130
Total	5,551	9,253	12,877	29,390

* Derv = diesel-engine-road-vehicle.

The growth in consumption of fuel oils has been notable. The most striking advance has been, perhaps, in steam raising, both for general use and for public electricity generation, the latter within the past year or so. Consumption of fuel oil at power stations last year was almost 2½ million tons. Another major category where the use of fuel oil has greatly increased is in steel manufacture, particularly in open-hearth processes, where fuel oil has played a notable part in the postwar development of the industry. The consumption of oil in the steel industry has more than doubled in the past 10 years, reaching nearly 1,700,000 tons in 1958. Something like two-thirds of steel made in Britain today is produced in liquid fuel-fired furnaces. Central heating is another rapidly developing end-use, and the potentialities here are very considerable. Ease of handling, greater controllability, and consistent quality give oil advantages over the traditional solid fuel, especially in the newer industries which are being established away from the older industrial centers. In the new towns which are being created in Britain, oil is the favored fuel. Possibly one in four of today's ordinary industrial and commercial consumers currently using solid fuel will have changed over to oil in the next three or four years. The passing of the Clean Air Act in 1956 may well speed up the process. Industries in which the use of fuel oil is already well accepted include glass, pottery, and ceramics; while usage in bakeries and food factories generally is increasing rapidly (see accompanying chart).

A similar trend is taking place in the use of gas-diesel oil. A widening range of industries is using the distillate oils for central heating and power purposes. Among the mobile diesel engines, the agricultural tractor now ranks the largest user of gas oil.

Britain has one of the most highly mechanized agricultural systems in the world today. The initial drive to mechanize British agriculture took place during the war, when the great majority of farm tractors produced operated on vaporizing oil—although, from a technical point of view, it had certain disadvantages. Now, however, that a handier lighter diesel tractor has been developed, gas-oil tractors are replacing vaporizing-oil tractors for agricultural work. In 1958, deliveries of the two fuels were almost exactly equal.

Following closely behind farm tractors in the use of gas oil is the general category of mobile diesel engines as used, for example, by building contractors; and almost equally important is consumption by stationary diesel engines, and by river and coastal craft. But the most important single end-use of gas oil is for gas making. Because of the shortage of the large carbonizing coal in recent years, deliveries of gas oil for gas making have been steadily increasing, reaching 580,000 tons last year.

The gas industry is turning more and more to the use of oil, and something in the nature of an application of modern petroleum technology is now taking place. This involves the catalytic cracking of oil in the gas works, as well as the use of tail gases from the refineries. The plants use a variety of oil feed stocks, and already 25 oil-gasification plants are in operation, with a further 14 under construction or on order. When these are completed, the total capacity of all oil-gasification plants will be in the region of 120 million cubic feet a day, and they will consume some 400,000 tons of oil a year—saving one million tons of the large coal which is in short supply. The latest experiment is for the importation of

liquefied natural gas, the initial cargo being of about 2,000 tons. After processing, this is to be fed into the gas system, and may prove the forerunner of further important developments in this field.

One other significant change which has taken place in the past few years has been the great increase in the demand for burning oil. In the past five years, consumption has doubled to 1,200,000 tons in 1958 from some 600,000 tons in 1953. Originally, burning oil was in greatest demand in the rural areas where it was used mainly for lighting and cooking. But, with the extension of rural electrification, this is no longer the case, and consumption now is mainly for urban domestic heating. This reflects the desire for a higher standard of heating in the home, which is not satisfied by the traditional open fire, particularly since the coming of television has brought about a revolution in social habits, with the hearth no longer the focal center of the home. There are now about eight million paraffin heaters in use in this country, and the number is still growing. Most brands of burning oil are marketed with distinctive colorings, some with a de-odorizing additive which further enhances the attractiveness of this method of domestic heating.

This situation is, however, but a precursor of a demand for full central heating. So far, in Britain, probably not more than 50,000 houses have oil-fired central heating out of a total of about 16 million homes.

Motor Fuels: Turning now to the market for motor fuels, the British vehicle population, while not comparable with that of the United States, is the largest in Europe and expanding at a steady rate. Since the war, the total number of vehicles has increased 2½ times—to nearly eight million from just over three million. The number of cars has risen in the same period to 4,700,000 from 1,800,000. Although the present high rates of taxation, both on the fuel (2/6d. per gallon) and in purchase tax on cars (at 60%), are affecting the rate of growth, it is estimated that by 1966 the number (including motor cycles) may rise to between nine and 10 million, with an additional two million commercial vehicles.

Until last year, very little construction of new roads had been undertaken in Britain; and, although a start has now been made, growing congestion is also a limiting factor. Consumption of motor spirit has not, therefore, been increasing at anything like the same rate as the growth of vehicles, particularly since the more efficient modern engines give a much lower fuel consumption. Compression ratios have risen steadily for several years, and 50% of new cars now sold in the domestic market have a compression ratio of more than 8 to 1.

In 1958, out of a total inland trade (excluding refinery consumption) for the British Isles of nearly 30 million tons, motor spirit accounted for only 6.9 million tons. Nevertheless, motor spirit is still the product best known to the general public, and the garage is the most important way in which the oil companies can keep their names constantly in the public eye. There are some 38,000 sites selling motor spirit, but this figure is not very different from the number of retail outlets in 1938.

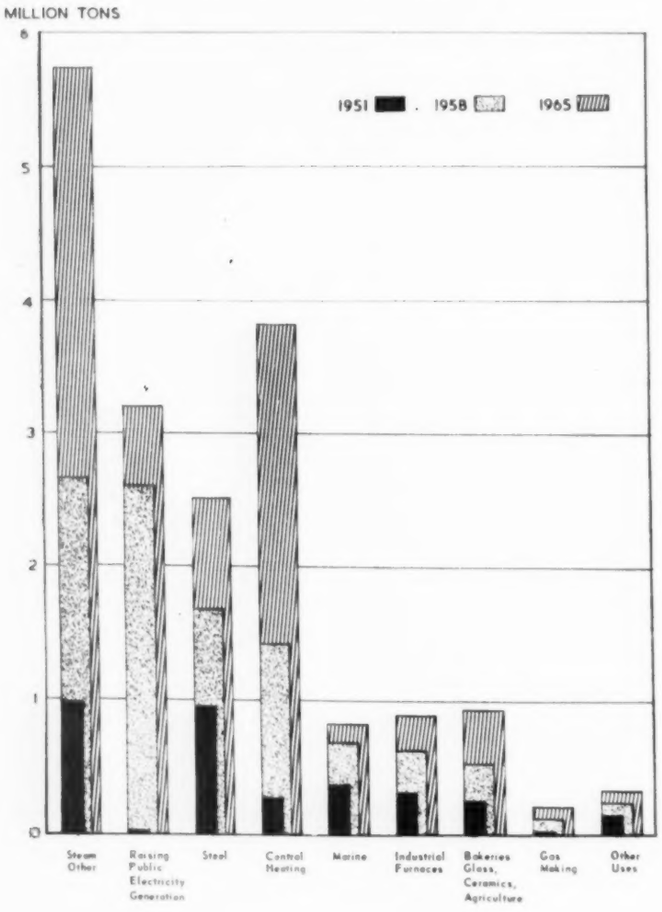
The structure of the rental market has changed fundamentally during the past few years. The multi-brand outlet survived in Britain long after it had been abandoned elsewhere. The change in the pattern of new towns and in improved roads, and the shift in the siting of the best selling points from the center of towns to the outskirts, have led to a program of investment in new service stations and the modernization of existing ones. The oil companies themselves have built a limited number of stations, and at the same time there has been a steady closing down of small and inconveniently sited garages in the more congested parts of the large towns. In this way, the retail marketing of motor spirit has been brought up to modern standards, with practically no increase in the number of outlets.

As elsewhere in the world, the emphasis in motor-spirit marketing has been on improvement in quality. Motor spirit with an octane rating of 100 was introduced to the British market in the middle of 1956, and in the past 2½ years has been very successful. Britain is still the only country in Europe with 100-octane brands, and this has been of great assistance to the highly successful British motor industry. Average research octane rating of premium grades is 96, and of ordinary grades is 82: and the proportion of premium grades to total motor spirit at 57% is probably the highest in the world.

For commercial vehicles, motor spirit is playing a somewhat less important part than formerly, as owners of heavy-goods vehicles are switching over to the more efficient diesel engine. In Britain, the tax on diesel-engined road-vehicle fuel is the same as that on motor spirit, in contrast to most European countries where this tax is much less. The volume of goods traffic in the United Kingdom in the past 20 years has risen by 50%, roughly the same as the increase in industrial production, and more than two-thirds of all goods vehicles of three tons and over are now powered by diesel engines.

Deliveries of derv fuel have thus shown a considerable upsurge in recent years, and the rate of change is being maintained as diesel vehicles extend into the lighter categories. The London taxi fleet is now almost entirely diesel. On the other hand, the bus companies, which have long been users of diesel vehicles, are beginning to contract their services as private transport grows and social habits change.

Fuel-Oil End-Uses—1951-1958-1956



Aviation Fuels: As a main center of the world's air communications and the home of an aircraft industry which has pioneered some of the greatest technical achievements in aviation, Britain's requirements of aviation fuels are already impressive, and the field for expansion remains still considerable. In view of the short distances involved, the development of internal air services in Britain is relatively limited; but, in the international sphere, London Airport, already the largest and busiest in western Europe, is now supplemented by Gatwick Airport, which is the first aerodrome in the world to have a railway station as an integral part of the airport terminal, while at the same time, its road approach incorporates the first free-flow intersection in the country.

The advent of the jet airliner, which consumes fuel in prodigious quantities, has sent up demand at a rapid rate. The demand for turbine fuel passed that for aviation gasoline in 1955, and in 1958 was nearly three times as great. Two grades of turbine fuel are marketed; but, because one, Avtag, is a wide-cut gasoline, it attracts a tax of 2/6d. per gallon—and its use is, therefore, more restricted than that of Avtur.

A main problem of the oil companies is to evolve fueling vehicles and hydrant installations capable of catering to the greatly increased requirements of bigger and faster aircraft. Thus, while the Dakota airliner only took some 680 gallons of gasoline in 1946, the new Comet IV needs 8,990 gallons of turbine fuel. To increase flexibility and mobility in its fueling fleet, one major marketer, which fuels four out of five of the aircraft at London Airport, operates a short-wave radio system of control, the first company in the world to do so.

The Future: The future trend of consumption of petroleum products in Britain must be seen against a background of a rising output of goods and services, which is needed both to support a growing population at higher living standards and to fructify a sustained expansion in international trade, which is of such special consequence to the economy of the country. If one accepts the widely held target of a doubling of the standard of living within 25 years, it is clear that the increased requirements of energy—even making the most optimistic assessment of the availability of nuclear power—can only be provided with a greatly enhanced contribution from oil.

While there is no question of oil's entirely supplanting coal in Britain, there is a growing realization that the coal age as such has come to an end and that oil, both now and in the future—and soon nuclear power as well—must take up an increasing part of the load. It is equally clear that it is in the national interest that they should do so, each making its specialized contribution, deriving from those fields in which each has its own technical or economic advantages. Indeed, coal's own contribution has undergone technical change; for, whereas 25 years ago three-quarters was used directly, today much more than half is first processed into gas and coke or electricity.

Although there is room for differing on the total energy requirements of the British Isles in the years ahead, it would not be unreasonable to assume that in 1965 total demand might reach 290 million tons of coal-equivalent, rising perhaps to 345 million tons in 1975, compared with 240 million tons in 1958. The contribution of oil for energy to the increase of 42 million tons to 1965 might be expected to be in the order of 22 million tons of coal-equivalent, with coal and nuclear power each accounting for about 10 million tons. This would give a total inland market for all petroleum products in 1965, excluding refinery consumption, of close to 44 million tons, against the current rate of just under 30 million tons. This represents an average annual expansion of some 6%.

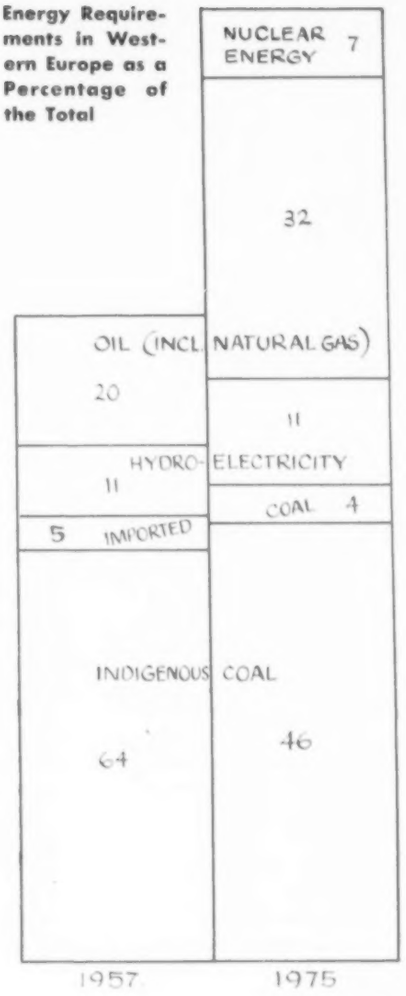
The British economy can certainly sustain an increase of this order. The country has an immense and growing stock of first-class capital equipment of all kinds and great resources of technical know-how and managerial ability. Opinion is unanimous that a policy of economic growth is the right one, both in relation to the movement towards a free-trade area in western Europe and beyond. Within the British Commonwealth alone, many areas which are rising to nationhood will provide an ever-growing market for the goods which Britain can produce.

In the severely competitive world in which we live, Britain will only attract and hold its customers if it can offer products as good in quality as those of anyone else, and equal to or better in price. It is this need for the British businessman to keep his production costs as low as possible which makes it essential that he have access to the cheapest resources of both fuel and raw materials.

Western Europe: The change and adjustments which are being made in British industry to meet the new conditions and altered outlook in the world today are indeed common to the whole of western Europe, which has similarly in the past founded its economic strength almost entirely on coal and which now seeks to have a wider and more diversified economy, which the indigenous fuel industries unaided cannot provide. All western Europe, therefore, has accepted the need for a steadily increasing contribution in the years ahead from the oil industry.

In 1956, the commission appointed by OEEC to examine Europe's growing needs of energy reported that western Europe's demand was likely to grow during the next 15 to 20 years at approximately 2½% a year. This is about double the average rate of growth over the past 30 years—although, in the period of rehabilitation after the war, there was a rise of more than 4% per annum between 1948 and 1957. With both physical and economic limitations to its ability to expand production on this scale, coal's share of total energy demand in western Europe, which now stands at rather more than two-thirds of the total, will drop to 50% by 1975.

Energy Requirements in Western Europe as a Percentage of the Total



As Mr. J. H. Loudon, president of the Royal Dutch Petroleum Co., has pointed out*—and the accompanying chart illustrates this—the supply and transportation of the great quantities of oil which western Europe will need represents a formidable challenge, but it is a challenge which can be met. It is clear that a great technological revolution is already in progress, and the realization of its full benefits can only be secured if the required supplies of energy are made available.

If one considers the fact that per-capita consumption of energy in western Europe today is under three tons (coal-equivalent) a year, and that this compares with a figure of eight tons for the United States, the scope for expansion is very great and the prospect of a doubling, or even a trebling, of oil imports into western Europe in the next 20 years is not at all an unlikely one.

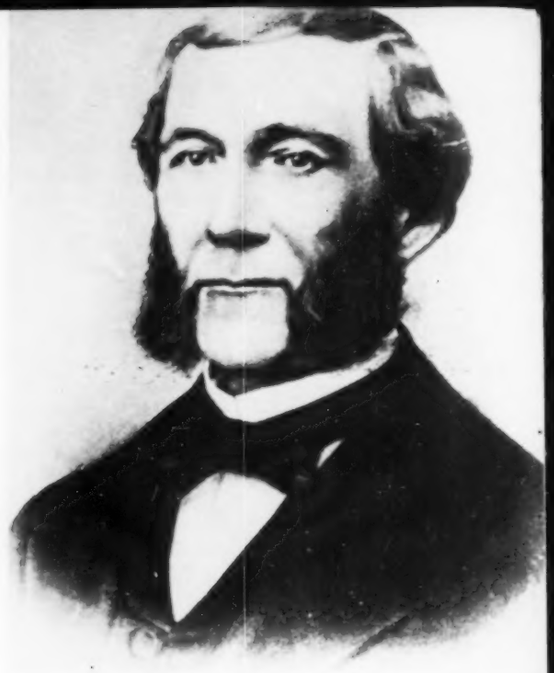
I, therefore, see the oil industry in the future taking its acknowledged place in the industrial life of Britain and the western European countries, sustaining their economies and contributing to a fuller life for their populations. END

* "The Importance of Oil to Western Europe—Now and In the Future": Address to Netherland Employers' Federation—September 1958.

OIL'S SECRET

by S. S. Smith

Since 1865, the oil industry has been able to keep prices low and build volume largely as a result of the low-cost transportation of crude and products by pipeline.



Samuel Van Syckel, father of oil pipeline transportation (API photo).

The oil industry is unique in that it provides its own transportation, which in total tonnage approximates one-half that handled by all the railroads of the USA. Its total mileage of pipelines exceeds the total of all railroad mileage. The products sold in filling stations are not carried, but are pumped from the oil well to the wholesaler. This is the great economic secret which has enabled oil companies to hold a price line which no other industry in the nation has been able to do, in the face of ever-increasing costs, and yet this segment of the industry has been the least publicized and least understood of the industry's many accomplishments. To shed light on the interesting techniques in use in pipelines, WORLD PETROLEUM presents the following article outlining the important technological developments which have taken place in the past, as well as the far-reaching developments now in progress.

The author separates the history of pipelining into three distinct periods viz:

1. The crude line manually controlled and pumping from surge or float tank to float tank.
2. The semi-automatic line pumping directly from station into station intake line with automatic control of station throughput but manual operation of units within each station.
3. The development period now in progress, which will ultimately result in whole pipeline systems all controlled from a central control point and using computers to shorten the tedious and time-consuming scheduling and dispatching.

Before Colonel Drake's well in Pennslyvania, the skimmings from oil seeps along Oil Creek were carried in five-gallon kegs on horseback to Pittsburgh. Eventually, this "Seneca oil" found its way into the apothecary's stocks.

Later on, when the oil excitement started, the teamsters took over transportation to the nearest railhead. Finally, in 1865, when the mud holes grew deeper and the teamsters more demanding, a bright young man named Van Syckel borrowed $30,000 and built the first successful USA pipeline. It was only six miles long, and only of 2-in. screwed and coupled wrought-iron pipe, but it carried 800 bbl daily at $1.00 per barrel tariff and paid Van Syckel quite handsomely. Other short lines followed in short order; and, despite opposition by and even pitched battles with the teamsters, these lines soon became the accepted practice.

However, in the early decades, no one seems to have realized that pipelines were more economic than rail transportation, and thus the pipelines remained an adjunct to the railroad and originally were owned or controlled by the railroads. In the meantime as refineries were built on the East Coast and at population centers like Cleveland, the stronger refiners acquired or built pipelines to use as levers in rate negotiations with the railroads. And, as these refining groups with their crude purchasing power grew in strength and gradually merged into or were acquired by the Standard Oil group, the pipeline became a powerful tool in dealing for rates with the railroads and even enabled the pipeline owners to command rebates from the railroads on all oil shipments.

As a result of these conditions, independent producers formed the Tidewater Pipe Line Co. in 1878 and built a 6-in. pipeline from upper Pennsylvania to Williamsport, Pa. This was the first long line of record, and the line was provided with two 80-hp crank and flywheel steam pumps which pushed the oil all the way to the destination. The boilers, strangely enough, were coal-fired rather than gas- or oil-fired. In fact, it is recorded in the *Oil City Derrick*, which was for many years the official oil-country publication, that the first attempts to gas-fire steam boilers were considered unsuccessful because the gas fire would not produce enough steam.

The Tidewater line proved a success and soon was followed by the National Transit line from the "oil country" to the eastern seaboard. National Transit was the first long link of the Standard Oil system which later extended to all the major fields of Pennsylvania, West Virginia, Ohio, Indiana,

Barge transportation of oil in early Pennsylvania fields (Drake Museum photo).

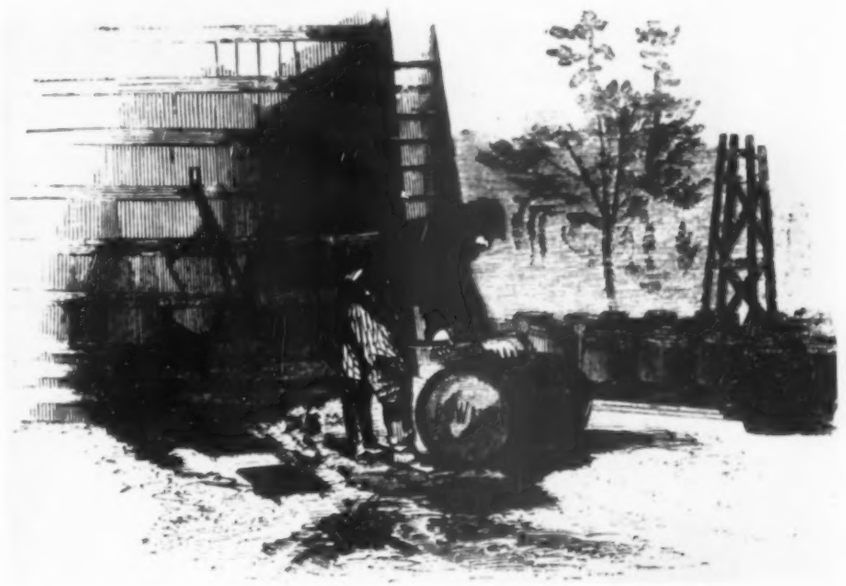
Illinois, and finally Oklahoma and Texas. These two lines and those which followed ended the oil transportation monopoly which up to this time had been enjoyed by the railroads.

Available history records little of the operating or construction techniques of these early ventures in pipelining, although we know that the early lines were built with wrought-iron pipe and that they were universally powered with steam. The first pumps were crude attachments to a crank and flywheel steam engine, which were shortly followed by the slide-valve duplex steam pump. Control, as we now know it, was nonexistent, and pipeline engineers designed pipe size and pumping equipment by "rule of thumb" or experience factors. Since each pump station received its oil in a surge or float tank and relay pumped from that tank to the next station, communication was usually established over a telegraph wire; and for many years, even up to this author's memory, the pipeline dispatcher's chief qualification was that he could operate a telegraph key and read a telegraph sounder, and the same requirement devolved upon the pump-station operator. It must be remembered that, in those early pipeline days, crude was not transported for customers as is the present custom. Instead, the pipeline bought the crude and issued crude-oil certificates to the producer. In turn, the producer could trade his certificates to a crude buyer in an oil exchange in the same manner a wheat trader now buys and sells wheat futures. In these circumstances, crude-oil shipments lost their identity when they entered a pipeline, and the refiner buying crude had no idea where it originated. So the pipeline dispatcher worked his stock of oil along the line by keeping account of volumes in tank farms and station float tanks and sending pumping rate instructions to each station as required to keep things in step along the line. Thus we see that float tank operation became the rule in all long crude lines, and this practice continued until about 1930.

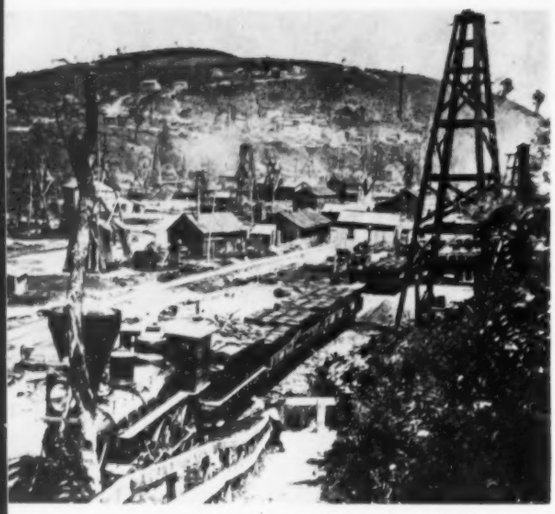
In 1901, a second independent group built a quite outstanding pipeline. This was done by Louis Emery and associates, and it should be noted that for many years Louis Emery was the outstanding champion of the small independent producer who sometimes flourished but often had a tough time in the early days in Pennsylvania. This line was the U.S. Pipeline, and it later gave start to The Pure Oil Co. and became an integral part of that company's operations. The line was, in fact, two lines—one 6-in. line for crude oil and one 5-in. line for refined products. In 1901, the principal refined products were kerosine and light fuel oil. Gasoline was still a byproduct, in some cases even being so much a surplus that it was burned or poured down a nearby river. The U.S. refined products line handled two grades of kerosine and a light fuel oil, and apparently had no mixing difficulties in transporting those several grades in succession through the same line. The line continued in operation until 1926 as a part of The Pure Oil Co., and a portion of its original right-of-way is still used by the Sun Oil Co. near Marcus Hook, Pa. While this line foretold the long product line of today, no other company followed its lead during the life of the U.S. line, and the industry in general seems to have entirely missed the significance of this achievement; for, in the early 1920's, a proposed gasoline line project in the Mid-Continent was abandoned apparently in fear that different grades of product could not be satisfactorily handled.

As the large Mid Continent fields came into being, crude-line sizes increased to 8-in. and 10-in. lines from 6-in. With these larger lines and their larger power requirements, it became important to accurately design for specific pumping rates. At the turn of the century, Stanton and Powell had run laboratory experiments to define the mechanism of fluid flow and the effects of gravity and viscosity. It remained for William Heltzell of Stanolind Oil Co. to reduce their data to English unit engineering factors and to confirm and modify Stanton and Powell's data into usable form for the long-line designer. His experiments and conclusions were published in 1928 and became a workable tool in the hands of pipeline engineers.

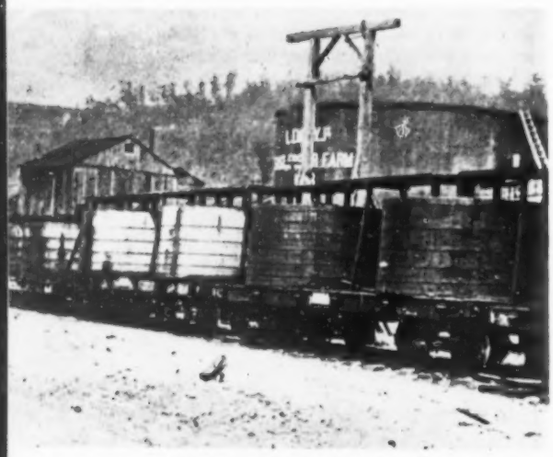
In the early 1330's, a number of gasoline lines were built. By this time, gasoline was the principal refinery product and volumes of gasoline manufactured had become so great that economics required cheaper means of transport. At about the same time, gasoline specifications were generally standardized to meet government specifications and to facilitate intercompany exchanges. In the East, Sun Oil Co. built the Susquehanna gasoline line; Standard of Jersey transformed Tuscarora Pipeline from crude moving eastward to gasoline



Filling wooden barrels with oil from tanks (Drake Museum photo).



Oil Creek Railroad near Rouseville, Pa.: First oil cars were regular flat cars on which oil barrels stood on end (Drake Museum photo).



First railroad tank cars, devised by Amos Densmore in 1865, consisted of ordinary flat car with two wooden oil tanks (Standard of California photo).

moving westward; Atlantic Refining Co. built its Keystone gasoline line; and Socony built lines in Pennsylvania and later in Massachusetts. In the Mid Continent, Phillips and Great Lakes companies built lines from Mid Continent refineries to Kansas City and Chicago areas. Originally, all of these lines were designed to transport their paternal oil company's gasoline except Great Lakes, which operated on a standard specification gasoline which was agreed to by the several participating and owning companies.

From an engineering standpoint, the Sun line was outstanding among these lines. From the start, its intermediate stations were built to operate automatically in a closed system. The stations were manned by a caretaker operator who was housed on the property, but his duties were confined to housekeeping and maintenance work. Communication between central office and terminals and pump stations was by teletype, thus taking advantage of the accuracy and in acknowledgment of the written rather than the spoken or telegraphed order. The stations operated automatically in conformity to the throughput at each station. Flow in the line, determined by an orifice meter at each station, started or stopped the single-unit motor-driven centrifugal pump. When "on the line," each pump was throttled to match line rate using pneumatic controllers and double-seated throttle valves on the discharge of the pump. If an upstream terminal took product from the line, only those stations operated which were required to pump the residual stream. As a single gasoline was handled, no commingling or mixing of products was involved. The stations on this line contained all of the principal features used in the most modern automatic stations; and, so far as this author knows, the Sun line was the prototype of all modern tight-line operations and the first line to discard the use of a float or surge tank at each station.

There was an earlier automatic station on a natural-gasoline line built in 1927 by Shell Oil Co. in California, but this station used a surge tank, and floats in the surge tank provided the "on-and-off" and throttling controls to keep the station "in step" with the line.

At about the same time the Sun gasoline line was built, a group of engineers working as an ASME committee in Tulsa designed what is probably the first fully automatic crude-line station, which also depended upon the use of float tanks for control.

Thus it seems realistic to break up the progress of pipelining into three phases or periods. The first of these was the float tank line; the second was the tight line in which each station pumped directly into the next station intake; and the third phase, now more or less in progress, is the centrally controlled and automatic tight-line operation.

The first period covered all of the early pipelines which handled crude and covered the time span of 1865-1930. During this operations period, the industry progressed from the makeshift steam pump stations of the early days through the use of the Corliss steam engine to the air-injection diesel and the electric motor. Pumps changed from the duplex to the long-stroke double-acting outside-packed piston plunger pump and, finally, to the high-speed vertical piston pump and the high-speed centrifugal. Probably the most significant of these developments is the high-speed centrifugal, whether driven by direct-coupled motor or the geared diesel. In either case, the ease of control, and the freedom from pressure surge which is characteristic of the centrifugal, is almost a requirement for the modern high-pressure tight-line operation.

Still in this arbitrarily selected first period, the industry also made many significant steps of progress in materials and methods of construction. Wrought iron was replaced by steel; and, in the early 1910-20 period, torch welding was developed for pipeline use, this being soon followed by the arc-weld with its higher strength and compatibility with higher-yield steels. Thus the major progress made during this first phase provided all the necessary equipment to permit the second period of automation.

In 1937, Shell Oil Co. laid a new 8-in. products line from Wood River, Ill., into central Ohio. This line provided several important steps of development in that it was the first major pipeline which, on top of the concept of semi-automatic operation, went into the concept of precision pipelining, wherein all volumes were meter-measured, regular two-week-cycle batching was initiated, dispatching was made dependent upon precision measurement and assisted by a visual board which laid out all the 60 F corrected barrels on a calibrated table whose length could be corrected to accord with operating temperatures and pressures. New meter calibrating techniques were first used on this line; initially, the calibration tanks were sprayed to equilibrium with the product on which the meter was to be factored; and later the "measured mile" was originated in which the passage of a close-fitting scraper, through a calibrated length of line, was recorded on a meter counter by the in-line scraper trips. This line also was the first to remotely control a multistation line over its normal communication teletype system. This was a joint venture of Shell and AT&T which pioneered this type of control which has now become quite common. A decade after construction, this line also pioneered the use of in-line stream blending. Two of these automatic stream blenders proportioned rundown tank stocks from refinery tanks; added tetraethyl lead, dye, and inhibitors; and passed the finished blend at line pumping rates directly into the pipelines for transportation to terminals and filling stations. Because there existed no reliable data on interfacial mixing, an important result of the regularly batched cycle on the Shell line was a study of these charac-

teristics of products in pipelines. Shell originally began this work at the University of Michigan, later transferring the work to its own laboratory at East Chicago. The results of this work were published by Smith and Schultze and became, for interfacial mixing, the same sort of reference work which Heltzell's work had become for the flow of liquids in pipelines. Their data enabled pipeline engineers to predict with good accuracy the amount of mix between any two products or crudes in any size line, without which data present-day large-diameter pipelines might not be practicable.

The Plantation Pipeline, built in 1940, was noteworthy in that it applied batching techniques on a regularly cycled basis for a number of different companies, each transporting several products. This line, which runs from Baton Rouge, La., to North Carolina and Tennessee, handles products for 13 or more companies and delivers specification products to each shipper. Plantation is probably the outstanding products line in the world in consideration of its length, size, and volume and number of products handled.

When the tight-line concept with fully metered volumes and precision dispatching was developed by the products pipelines, it was immediately apparent that these improvements would also serve the crude pipelines. These techniques were immediately adopted by the crude lines and became increasingly significant as octane values of fuel increased and as better lubricants were required for higher-compression engines. These requirements placed a heavy premium on ability to segregate special crudes for charging stocks to refineries, and took place at about the same time that older small-diameter and sometimes multiple-looped crude lines were being replaced by larger-diameter single lines in the interest of better economy. Thus the crude-line operators found the same requirements for batching crudes as did the products-line operators. In many cases, the larger volumes of crude handled required multiple-unit pump stations operated either in series or parallel, but in either case requiring more complex control equipment for complete automation. Moreover, because of the number of units involved, there existed a need for larger maintenance forces, so that there was not the same impelling economic urge for complete automation which paid so well on the smaller-diameter products lines. The course of automation in crude pipeline stations has, therefore, quite logically developed along the general idea of eliminating the hard and slow manual valve operation and engine or motor starting, but usually ending with push-button operation of individual units in the station. Thus the stations are usually manual, with control of "on-and-off" units by push button on the part of local operators directed by a central dispatching office. Unit throttling is automatic; all valves are motor-, air-, or hydraulic-operated, and controls are brought to a central console from which control point all switches are controlled to and from tanks, etc. In the determination of crude quality, a great deal of special instrumentation has been developed; this special instrumentation, particularly the instruments designed for detection of BS&W and gravity, have enabled the crude-line operators to automate their most costly labor item, V12, tank gauging for field receipts from producers. This new automatic custody-transfer technique has progressed along two parallel methods: (1) the automatic tank battery; (2) the positive-displacement meter route. Each has its advocates. In fact, each method has its proper place, depending upon quality and quantity of crude handled; but, in both cases, lease automatic custody transfer seems to be the most significantly important development to lower the costs and increase the accuracy of transferring custody of crude oils.

Pipeline communication has kept pace with all other technical developments, progressing from wire telegraph, to phone, to teletype and, finally, to microwave, either phone or tape.

All of these developments inevitably point the way to the upcoming third period of development, which will be the fully automatic and centrally controlled pipeline system. Significantly, this third period is already emerging from the design boards of progressive pipeline engineers. Examples of this trend are Wolverine Pipe Line, Badger Pipe Line, Four Corners crude-oil pipeline, the new Laurel products pipeline, and the Cherokee products pipeline.

Wolverine line has centralized control of all pumping, including remote control of an automatic diesel station operated from its station of origin over teletype remote control.

Badger uses phone line control of switching and remote valve operation using pulse and tone codes to set up changes of operation and report back operating conditions.

Four Corners crude line uses remote control to operate all pump stations under the direction of a conventional central dispatching office.

Laurel line is just getting well started in operation, but is set up to remotely control all operating units, to identify and report batch changes, and to set all offtake rates at terminals. Future additions to this line can easily include data reporting and computer analysis at a central control point.

Cherokee is at the time of this writing just "breaking in" new control equipment which abandons the conventional relay and mechanical switch components and substitutes solid-state transistors and diodes to control functioning of stations and report operating data to a central computer system to scan and revise operating conditions as necessary.

The ultimate in pipelining may well be a completely automatic system which can handle any combination of petroleum liquids with no personal supervision other than the service personnel to adjust and maintain the equipment which does the "thinking." One basic technique still necessary to this idealized operation is a means of positive separation of products or crude, so that not even minor mixing or downgrading takes place. The author ventures the thought that this item will soon be forthcoming, and that even this minor problem of multiproduct pipelining will soon be solved.

No mention has yet been made of the part which pipelines played in the last war. The history of this is well-known, but bears repeating. The Big Inch and Little Inch lines, built from materials which could be obtained on short notice, were put together by dedicated pipeline men under conditions of near chaos brought about by the loss of tankers by submarine; and, without these lines and the reversal and re-adaptation of existing lines, the industry of the eastern United States would have been well-nigh paralyzed.

In the field of military operations, the portable pipelines designed and manned by industry men took a terrific load from overloaded highways and railroads and greatly speeded military operations in all fields. The Lido Road line and the lines in North Africa, Sicily, Italy, and western Europe accounted for some 17,000 miles of total pipeline, and transported gasoline, diesel oil, and aviation fuels for all important campaigns. END

S.S. SMITH, born in the Pennsylvania oil country, went to Oklahoma after World War I. Employed by Roxana Petroleum Co., he developed unit plant idea for gasoline extraction from flush pools of relatively short life. In 1938, he took charge of Shell's products pipeline department. Originator of many techniques which today are accepted practice in multi-product and crude pipeline practices, the US Army awarded him the Medal of Merit for his designs and instrumentation for portable pipelines during World War II and for his assistance in training pipeline service men.

With retirement from Shell in 1954, Mr. Smith became a products pipeline consultant, and is now engaged in design of proposed Foothills Pipe Line in Canada. He is author of numerous technical articles, and holder of patents pertaining to pipeline techniques.

Fishing fleet at St. Ives, Cornwall, taking on Anglo-Persian "Royal Standard" kerosine circa 1924.

Above: Aircraft fueling at London's Croydon airport in 1925.

Below: D'Arcy's first well (1902-1905) at Chiah Surkh in Persia, on doorstep of what is present-day Iraq.

GOLDEN

THE oil industry is celebrating this year the centenary of the drilling of the world's first commercial oil well, but for one of the organizations in the industry 1959 has a special significance. On April 14, The British Petroleum Co. celebrated its Golden Jubilee. This marked 50 years of existence in which BP has grown from a relatively small company, in a field which was already dominated by large groups, to one of the major international oil organizations with interests spread throughout most of the free world. The group is today engaged in all phases of the industry—including exploration, production, sea transport, refining, petrochemicals, marketing, and research.

The British Petroleum Co. was registered under its original name of Anglo-Persian Oil Co. in 1909, but its history dates back to about 1900, when William Knox D'Arcy, who had made a fortune in gold in Australia, became interested in the possibility of exploiting the oil which had been known to exist in Persia from ancient times. On May 20, 1901, he was granted an oil concession by the Persian government, valid for 60 years, "to search for, obtain, exploit, develop, render suitable for trade, carry away, and sell natural gas, petroleum, asphalt, and ozokerite through the whole extent of the Persian Empire with the exception of the five northern provinces . . ."

Years of unsuccessful and expensive exploration for oil followed, until eventually the Burmah Oil Co. took over operations. On May 26, 1908, when funds were on the point of exhaustion, oil was struck in commercial quantities at Maidan-i-Naftun (since renamed Masjid-i-Sulaiman) almost exactly seven years after the grant of the concession. The Anglo-Persian Oil Co. was formed a year later to operate the original D'Arcy concession, which was transferred to the new company.

A site for a refinery was chosen on a barren mud flat on the Shatt-Al-Arab River, called Abadan, and a pipeline connecting it with the Maidan-i-Naftun oil field was completed in June 1911. The refinery did not function normally until 1913, when it had an annual capacity of 400,000 tons, which seemed considerable in those days.

It was difficult for a relatively small company, as the APOC was in those days, to get a footing in the international oil market; but in May 1914 came two valuable developments. The British Admiralty entered into a long-term contract with the company for fuel oil for the Royal Navy, and the British government invested £2 million in it.

After World War I had broken out, the company had to push forward its expan-

JUBILEE OF BP

William Knox D'Arcy.

sion program hastily in circumstances of greatest difficulty. By 1917, however, the most serious obstacles had been overcome, and the company was able to embark on a program of development both in the oil fields and at Abadan. About this period, a start was made in the building of the company's tanker fleet.

The 1914-18 war was followed by another period of expansion, including the building of the first major refinery in Britain at Llandarcy, and the extension of the company's marketing system to Europe and to Australia.

In 1933, the original concession in Persia was revised, the area being reduced to 100,000 square miles, but the term extended to 1993. In June 1935, the company changed its name to Anglo-Iranian Oil Co. to conform with the ancient name of Iran, which had officially replaced Persia as the name of the country.

In the meantime, the company had acquired approximately a quarter share in the Iraq Petroleum Co., and had entered into equal partnership with Gulf Oil Corp. (USA) to form jointly the Kuwait Oil Co.

World War II struck the company in every branch of its spreading organization. Its operations reflected the changing fortunes of the war—at first, cutrailments; then, when the allies went from victory to victory, a great expansion. Abadan's production of 100-octane aviation spirit was initiated and rapidly developed to meet demands from the allied forces, about a million tons of aviation spirit yearly being produced by 1944. From then until 1951, Persian oil production increased yearly and Abadan—by now the biggest refinery in the world—attained by 1950 a throughput of 25 millions tons a year. By then, the company was employing 75,000 people in Iran (all Persian except about 4,500 British, Indian, and Pakistani) who, with their families and dependents, made up a community of nearly 200,000 whose annual wage bill amounted to £24 million.

The events which led up to the standstill of the company's Iranian operations in 1951 are too well-known to need detailing here. Suffice it to say that, after some three years of discussion and negotiation, the dispute with Iran was settled. The British Petroleum Co. (the name was changed in 1954) and seven other leading oil companies together formed an international consortium to handle Persian oil. These eight companies were later increased to 17 by the addition of nine smaller American oil companies. BP has a 40% interest in the consortium's oil operations.

The standstill of operations in Iran accelerated a major change which had been taking place in the group's activities since the end of World War II. Due to a number of factors—including the advent of larger tankers, bigger consumer markets, and the development of petrochemical industries adjacent to refineries—it was becoming an economic advantage to site new refineries in the large consuming areas such as western Europe, rather than in producing areas like the Middle East.

In 1951, BP had already completed a considerable expansion of its refining capacity in Europe. With the loss of Abadan, it went ahead to develop projects in hand for new refineries and further refinery extensions.

In 1953, the new refinery on the Isle of Grain was commissioned; and, during the same period, postwar development projects at the company's other main United Kingdom refineries at Llandarcy and Grangemouth were completed. About this time, also, work started on the construction of two entirely new refineries at Aden and at Kwinana, Western Australia.

Parallel to the development of its refining capacity, the company increased and widened its other activities—including exploration, transport, and marketing. BP acquired an interest in exploration companies in Canada and Trinidad, as well as intensifying its search for oil in many other parts of the world. The bulk of the group's crude oil still comes from the Middle East, but it is now from jointly-owned production companies rather than from wholly owned interests.

Thus, despite the setback of 1951, by 1955—the time of the third World Petroleum Congress—the BP group had not only made up lost ground but, in many respects, had surpassed its 1950 levels of activity. The past four years have been marked by a continuing expansion and consolidation of the group's interests. As a key to its worldwide development, BP has carried out a number of major expansion projects covering all phases of its activities in the United Kingdom.

Kent Refinery: One of the biggest developments has been at BP's Kent refinery on the Isle of Grain, where work costing some £30 million was completed in 1958. The refinery was commisioned in February 1953, and some three years later a major expansion was begun. This had two main purposes. The first was to raise crude-oil distillation capacity to 140,000 bbl per day from 90,000 b/d, thus increasing the potential output of all the main products to meet rising demand from markets in the United Kingdom and northwestern Europe.

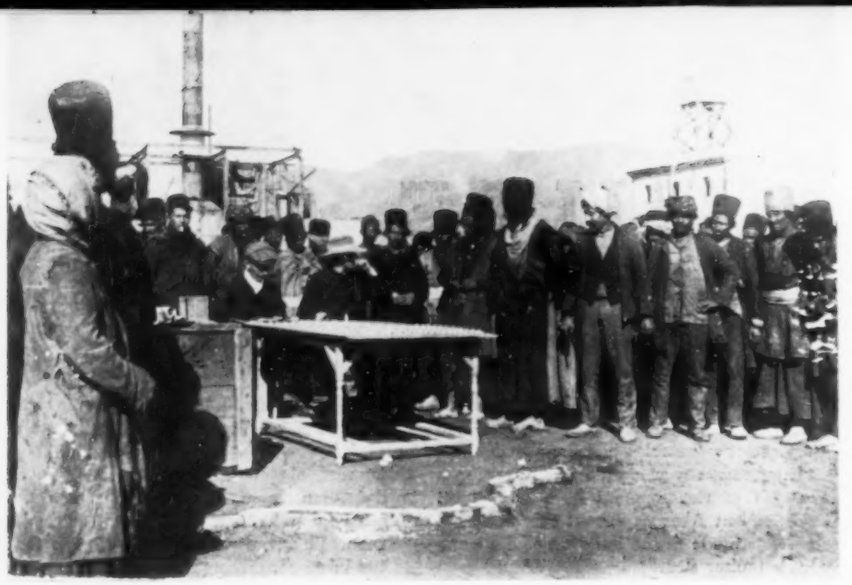
Second, the refinery was to be equipped to produce aviation gasoline. With this project now completed, Kent refinery has the only complete range of plant for making aviation gasoline in the United Kingdom. It can produce 140,000 tons a year with an estimated saving in overseas dollar expenditure of $8 million. The expansion plan involved the construction of 21 new processing units, as well as 122 new storage tanks and additions to plant to generate more steam and electricity. Two new deep-water jetties, equipped with the latest type of overhead gantries for discharging and loading, and several smaller jetties, have been erected on the River Medway.

On a site adjoining the refinery, there has been another important development. This is the South Eastern Gas Board's project to produce town gas from oil. For the first stage of the plant, the board is using its own Segas catalytic gasification process. The initial units were commissioned in October 1958, and at present the plant can produce 20 million cubic feet of gas a day for which it uses up to 3,000 b/d of feed stock supplied by Kent refinery. A wide range of oil products can be converted into gas. A second stage, which will double capacity of the plant, is due for commissioning in autumn 1960. The gas produced is distributed through a pipeline grid to consumers in southeastern England and London south of the Thames.

Grangemouth: At the time of the Fourth World Petroleum Congress, an expansion project at BP's Grangemouth refinery in Scotland had just been completed. This raised the refinery's capacity to 44,000 b/d from its prewar figure of about 7,000 b/d. In 1957, work began on a £6 million project to raise crude-oil distillation capacity by 20,000 b/d, to 64,000 b/d. The new crude distillation unit came onstream last January, and the whole project is to be completed in 1959.

Since 1915, Grangemouth refinery has re-

A "gusher," with wooden derrick typical of days when precautions to control oil flow were not always adequate.



"Pay day" in Persia in company's early days (circa 1910).

ceived its crude-oil supplies through a 57-mile pipeline across Scotland from the Finnart ocean terminal on Loch Long. The terminal was originally built because Grangemouth docks could not accommodate the increasingly large tankers which have been used to bring crude supplies from the Middle East in recent years. To allow the biggest tankers envisaged to berth at Finnart, a new jetty and tankage costing £2 million were completed in September 1958. The capacity of the pipeline has been raised to 65,000 b/d from 40,000 b/d.

Petrochemical: Adjoining the BP refinery site at Grangemouth are the plants of British Hydrocarbon Chemicals Ltd., and its subsidiaries—Forth Chemicals Ltd. and Grange Chemicals Ltd. BHC, a joint interest of BP and The Distillers Co. Ltd., was formed in 1947 to manufacture petrochemicals from feed stock supplied by Grangemouth refinery. The first units started production in 1951, and since that time there has been a spectacular and continuous growth in its operations.

A number of new plants have been commissioned in the past four years. At the end of 1955, the plant of Grange Chemicals (joint subsidiary of BHC and the Oronite Chemical Co. of California) was completed to produce detergent alkylate, an intermediate for synthetic detergents. The monomeric styrene plant of Forth Chemicals (joint subsidiary of BHC and Monsanto Chemicals Ltd.), which started operating in 1953, was expanded to four times its initial designed capacity in 1956.

In late 1956, a second ethylene plant was completed. This doubled production capacity for the basic olefins used by BHC and its subsidiaries to manufacture petrochemicals. Some of the additional ethylene production is being supplied to Gemec Ltd., which recently completed a factory at Grangemouth for the manufacture of polyethylene. A butadiene plant was commissioned in November 1956, and a tetrapropylene unit started operations in March 1957.

Planned for commissioning during 1959 are a plant for the manufacture of polyethylene by the Phillips' low-pressure method, and another to make phenol by The Distillers Co.'s process.

Work started in October 1958 on the installation of a third ethylene plant for BHC. This will more than double the present 60,000-tons-per-year ethylene capacity at Grangemouth, and will be the largest plant of its kind outside the USA.

When these additions have been completed, total investment at Grangemouth by British Hydrocarbon Chemicals will amount to £33 million.

Llandarcy: In south Wales, the main developments by BP in the past four years have been associated with improving facilities for importing crude oil for Llandarcy refinery and for exporting its refined products. At Queen's Dock, Swansea, the port for Llandarcy refinery, a new jetty for loading products onto coastal tankers was opened in March 1956. This project, which cost about £600,000 with associated tankage, marked the completion of the postwar modernization of the oil installations in Queen's Dock.

Work is well advanced at Angle Bay, on the south side of Milford Haven, on construction of a new deep-water port for Llandarcy. This £6,500,000 project, which had been under consideration for several years, was embarked on at the end of 1957. As with Finnart, the project became necessary because of the increasingly large tankers being used to bring crude oil from the Middle East. Though equipped with modern jetties, Queen's Dock, Swansea, cannot accommodate tankers exceeding 20,000 dwt due to restrictions at its entrance.

The Angle Bay project includes a large jetty extending into the Haven from Popton Point, with deep-water berths for two of the biggest tankers envisaged; a shore installation with offices and water and bunker oil storage to service the tankers; a tank farm 1½ miles to the south to store the crude pumped ashore by the tankers; and a 60-mile pipeline with a capacity of 100,000 b/d to carry the crude across south Wales to Llandarcy refinery. The terminal and pipeline are expected to be commissioned in the middle of 1960.

Research: Throughout its history, the BP group has given high priority to research. The past four years have witnessed a major expansion of the group's main research establishment—the BP Research Center, at Sunbury-on-Thames, near London. In November 1956, the new motor-engine-fuels test laboratory was opened. This laboratory includes a chassis dynamometer room where cars can be tested under different road and temperature conditions and speeds of up to 120 mph simulated.

Earlier in the same year, a £1,500,000 expansion project was started. The main two new buildings, which were completed in 1958, are a large three-story analytical and physics laboratory and a 27,000-square-foot exploration and production laboratory. The latter unit was previously housed at Kirklington Hall near Nottingham. In addition, a new workshop, a main stores building, and a restaurant block have been built, while a new building to accommodate the process development laboratory is under construction. To extend and speed up research into the radiation chemistry of petroleum products, a linear accelerator was installed in 1958.

BP's growing interest in petrochemicals was reflected at the end of 1958 by the formation of a new chemicals division at Sunbury.

Oil Production: Though United Kingdom crude-oil production is modest in total, BP has played a major role in discovering and developing these indigenous resources, while the group's subsidiary, Scottish Oils Ltd., operates the Scottish shale-oil industry.

There have been a number of encouraging oil discoveries by BP Exploration Co. in the English Midlands in recent years. In 1955, oil was first found at Egmanton, Nottinghamshire. This field has since proved to be the largest yet discovered in England, and contributed nearly half the 1958 total production of just under 80,000 tons.

Further discoveries were made at Langar,

Pipelaying in Persia, February 1911.

Nottinghamshire, in 1957; at Bothamsall, Nottinghamshire, and at Corringham, Lincolnshire, in 1958; and near Gainsborough, Lincolnshire, early in 1959. These newer fields are still being proved. Exploration in other areas of the United Kingdom, both for oil and natural gas, is continuing.

Tankers: BP has been actively developing its shipping interests over the past four years. In 1955, the BP Tanker Co. announced a £52 million building program for 283 tankers for delivery during 1958 and 1959. This program includes the company's first seven tankers of 42,000 dwt, as well as 15 of 35,000 dwt and one of 32,000 dwt.

In 1956 orders were placed for nine motor tankers of about 14,000 dwt, also for delivery in 1958 and 1959.

BP's biggest tanker-building program to date was announced in June 1957. This totaled 26 ships with an estimated cost exceeding £80 million. As later revised, the program includes seven vessels of 65,000 dwt and 11 of 50,000 dwt—all for delivery between 1960 and 1963. All of these ships, except six, were ordered from British shipyards.

A number of ships in the 1955 and 1956 building program have already joined the BP Tanker Co.'s fleet. "British Duchess," the first of the 42,000-tonners, went into service as flagship of the BP fleet last October.

Crater-like trap collects oil at Maidan-i-Nattun, about 1926. With light fractions first burned off, flames were extinguished before oil was drawn off through underground channel.

The enormous cost of these tanker-building programs has resulted in financing arrangements which have raised loans totaling £52 million. In addition to building programs for the group's British companies, new vessels are also being built for the French and Danish associated companies.

BP Tanker Co. and the group's other associated shipping companies have 167 vessels in service totaling 2,755,000 dwt. On charter to the group are a further 160 ships.

Overseas Refining: Outside the UK, BP has been just as active in expanding its interests. BP's new 60,000 b/d Kwinana refinery in Western Australia was commissioned in February 1955; and in following months various units, including a catalytic reformer and a hydrofiner, were brought into service.

An expansion project, completed early in 1959 at an estimated cost of £4,300,000 (Australian), included installing a second catalytic reformer with a throughput of 10,000 b/d to increase production of high-grade motor spirit.

In France, distillation capacity of Lavera refinery has been raised to 80,000 b/d from 44,000 b/d, while at the nearby associated Naphthachimie petrochemical plant, which uses naphtha feed stock from Lavera refinery, ethylene and propylene production capacity has been doubled.

Crude processing capacity has also been raised at Antwerp and Hamburg refineries. At Antwerp, where the refinery is jointly owned by BP and Petrofina, a 7,000 b/d catalytic reformer and an 8,000 b/d hydrofiner were commissioned in 1958. The group is currently building two new refineries, in the Ruhr, Germany, and in Canada; while it is associated with other companies in three other refinery projects—at Whitegate, Eire; in Turkey; and in Algeria.

In November 1958, work started in the Ruhr on building a new 90,000 b/d, which is also due for completion in 1960. At Dormagen, near Cologne, a new pertochemical plant is being constructed for Erdoelchemie GmbH, which is jointly owned by BP's German associate company and Farbenfabriken Bayer AG.

Perhaps the most significant development by the BP group in the past four years has been the extension of its activities to the Western Hemisphere. The first moves in this direction were the acquisition of the exploration and production interests in Trinidad and Canada, which have already been mentioned. Early in 1957, BP announced plans for building a refinery near Montreal to process crude oil and manufacture high-grade petroleum products to be sold on the Canadian market under the BP trademark.

These plans represented the first venture of the BP group into marketing and refining in the Western Hemisphere, and in the past two years they have progressed considerably. The company has now built or purchased more than 400 service stations in Quebec and Ontario provinces.

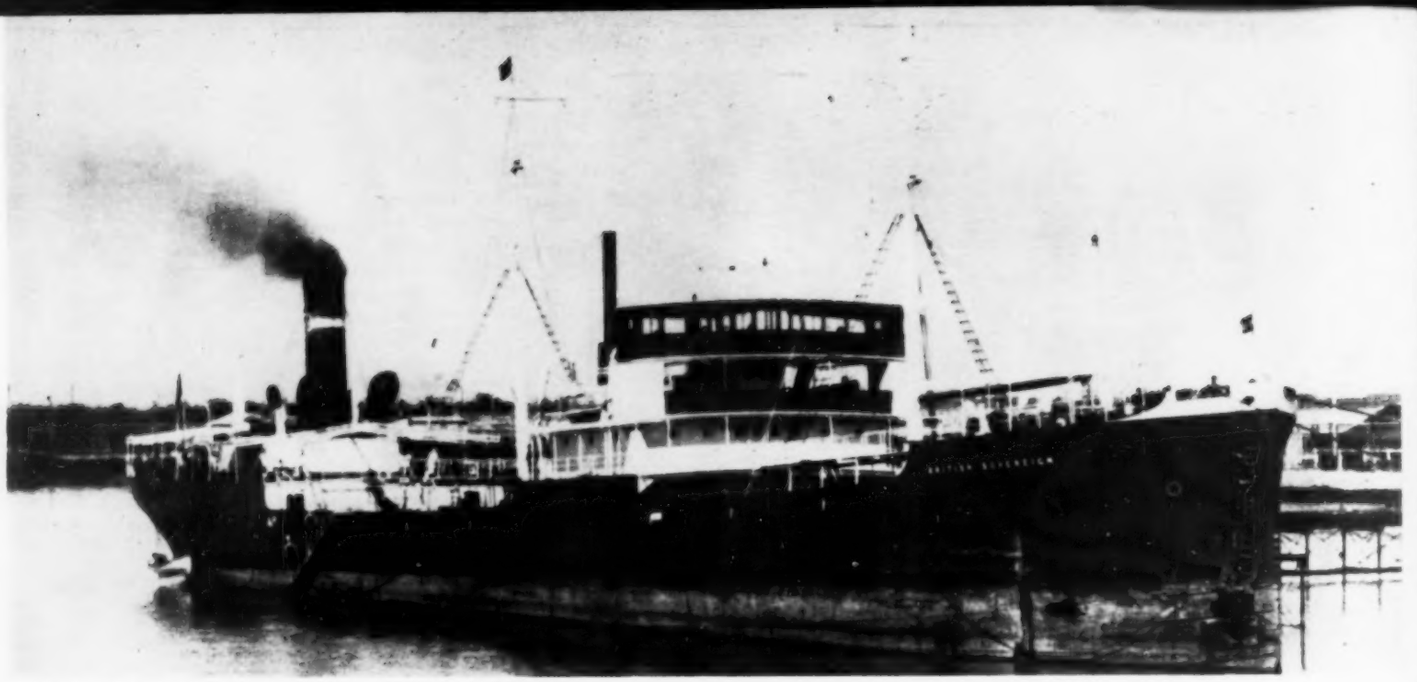
Work officially started on building the Montreal refinery on May 12, 1958. It is sited at Ville d'Anjou, at the eastern end of Montreal Island, and approximately three miles from the St. Lawrence River. Initial capacity will be 25,000 b/d, but the refinery will be planned to permit a future doubling of this capacity. The refinery is scheduled to come onstream in mid-1960. It will produce primarily about 2,800,000 bbl a year of motor spirit and, in addition, kerosine, gas oil, diesel oil, and fuel oil.

Tankers carrying up to 28,000 dwt of crude oil will be able to berth at a new 780-ft-long dock being built by the Canadian National Harbors Board on the St. Lawrence River. From the dock, a three-mile buried pipeline will carry the crude oil to the refinery. Crude oil will also be drawn from the pipeline connecting Portland (Maine) with Montreal. Some of the refinery's products will be distributed by water from the dock.

Exploration Expansion: BP, on its own or in association with other companies, has been intensifying its search for new oil fields over the past four years. In the Persian Gulf, off Abu Dhabi, nearly five years of preparatory work and some £5 million expenditure were rewarded in 1958 by an encouraging find of oil in the first underwater well to be drilled by Abu Dhabi Marine Areas Ltd., in which BP has a two-thirds interest and Cie. Française des Pétroles one-third. The barge "Adma Enterprise" is now drilling further wells to prove whether this oil find is a new oil field of commercial value. Operations off Abu Dhabi are serviced from a supply base specially built on the tiny Das Island, some 60 miles from the coast.

BP is searching for oil in Papua in association with Australian and American interests. To speed up work in the very difficult jungle terrain, large helicopters were introduced in 1957, and a number of test wells have been drilled with rigs flown in and serviced entirely by air.

In East and West Africa, BP is seeking oil



First BP tanker named "British Sovereign," built in 1917; 5,796 dwt.

jointly with the Royal Dutch-Shell group. Three deep test wells have been drilled in East Africa—on Zanzibar, Mafia Island, and Mandawa in Tanganyika. There have also been extensive geological and geophysical surveys in the coastal areas of Kenya and Tanganyika.

Early in 1958, the first tanker loads of crude oil from wells on test production in Nigeria were dispatched to refineries in Europe. Shell-BP Development Co. of Nigeria is continuing appraisal drilling in a number of districts, and oil has been found in several wells.

Companies in which BP is interested are actively exploring for oil in France and French North Africa. Test wells have been drilled in central and southwestern France, and in Senegal. Surveys are now being carried out in a number of exploration permit areas in Algeria, which the Ste. des Pétroles de Valence (Sahara) received last year.

BP Exploration Co. has drilled three test wells in Libya, and is currently engaged in new survey activities. The company is drilling its first deep test well in Malta, and is carrying out a new geological survey over its concession area in British Somaliland.

In Austria, BP Exploration Co. is searching for oil in association with Austrian interests. A seismic survey has been completed, and a test well is being drilled.

BP exploration activities in New Zealand are carried on jointly with the Royal Dutch-Shell group and local interests. A number of surveys have been carried out on North Island. On the west coast area, a test well is being drilled at Kapuni.

A geological survey party in Persia around 1910.

The group's exploration interests in Trinidad include a one-third share in Trinidad Northern Areas Ltd., which holds licenses to explore a number of marine areas round the colony's coast. Oil is being produced from several under-water wells.

In 1956 British Petroleum Co. made an offer to the ordinary stockholders of the Trinidad Petroleum Development Co., and it now holds 77% of the ordinary stock of TPD.

In Canada, BP is interested in exploration and production through its 50% shareholding in Triad Oil Co., which has producing oil wells in Alberta and exploration leases or reservations in Alberta, British Columbia, and Saskatchewan. In 1957, three useful gas discoveries were made by Triad in the Central Foothills area of Alberta, and last year a new oil field was discovered in the Beatton River area of northeastern British Columbia.

Marketing: There have been several recent major extensions of BP's marketing interests. In July 1956, 100-octane motor spirit—BP Super Plus—was introduced to the British market. New BP distributing organizations have been set up in the Belgian Congo, the Persian Gulf, Canada, Italy, and Algeria.

BP started marketing its products, for the first time in the Western Hemisphere, in Canada in 1957. By the end of 1958, there were some 400 BP service stations in the Montreal and Toronto areas.

The BP international oil bunkering service has continued to extend its operations, and it is today available to shipping at more than 190 ports throughout the world. During 1958, BP Energol marine lubricants became available at some ports in the Western Hemisphere for the first time.

The international aviation fueling service, now known as Air BP, has steadily expanded its network. It has placed special emphasis on developing modern fueling

Left is aerial view of Abadan refinery, 1918.

Below is site on which Abadan refinery now stands, as seen in 1901.

techniques to keep in step with new trends in aircraft manufacture.

Agreement with Sinclair: One of the most important developments for the BP group in the past few years is the agreement with Sinclair Oil Corp. (USA), announced last October. This provides for BP and Sinclair to cooperate in a number of ways, including the supply of Middle East crude under a long-term agreement for Sinclair's domestic needs; the establishment of a jointly owned company to market Middle East and Venezuelan crudes in the Western Hemisphere; and of another to provide for exploration and production ventures, primarily in Latin America.

The first of these companies is Sinclair and BP Sales Inc., which is to engage primarily in the sale of Middle East and Venezuelan crudes in the Western Hemisphere. The availability of crude supplies from both hemispheres provides this joint company with wide flexibility in meeting the needs of customers. At the same time, it will be a means whereby the resources of Sinclair and BP can be more effectively used in supplying demand. The company's president is Carl G. Drescher, a vice president of Sinclair Oil Corp.; and the executive vice president is R. D. Hull, formerly operations manager of BP Trading, London. Other appointments include William J. Farrell (formerly corporate sales relations manager of Sinclair Refining), vice president and general sales manager; Wayne Templer (formerly assistant to BT Trading's purchasing agent in New York), assistant general sales manager; and Jack Corlew (formerly assistant refining manager of Sinclair in Wyoming), planning director.

The second company is Sinclair and BP Explorations Inc., formed to engage in crude-oil exploration and production ventures, primarily in Latin America. Several foreign ventures are already under consideration. The president and chief executive officer of this new exploration-production organization is William O. Clift, previously general manager of Sinclair Somal, which is carrying out operations in Somalia, East Africa. A. F. M. Matthews, until recently in charge of BP Exploration Co.'s lands division, has been appointed senior vice president. Other executives who have joined the new company are: H. R. Warman (from BP), vice president and chief geologist; F. C. R. Martin (geologist, also from BP), who will establish an office in South America; and Raymond Halsey (formerly geophysicist with Sinclair Refining Co.), who will be chief geophysicist.

The offices of these new companies are located in the Sinclair Oil Building on Fifth Avenue, New York.

Finance: The many expansion projects in which the BP group has been engaged in the past few years have involved very large capital investment. In the three-year period 1955-57, capital expenditure by the group totaled about £229,500,000. This included £55 million for exploration and production, £68,500,000 for refineries, £26 million for tankers, and £80 million for distribution and marketing.

In 1958, capital expenditure was estimated at approximately £110 million, excluding other financing for tankers.

This very heavy expenditure has been financed mainly out of the company's own resources by ploughing back profits and drawing on reserves, but some recourse to outside finance has had to be made. In December 1957, The British Petroleum Co. Ltd. made an issue of £41 million 6% convertible debenture stock. The largest industrial capital issue ever made by a British company, it was more than 16 times oversubscribed, and was described in the UK press as "one of the most successful debenture issues ever made."

The company also made a pioneer financing move early in 1959. In March, it raised a loan of 60 million Swiss francs (about £5 million) on the Swiss market. The first loan to be raised on the continent by a British company since the war, this loan was organized by a group of Swiss banks. The proceeds of the loan will be used to finance expansion of BP's marketing operations in Europe, including the activities of the Swiss associate company.

At the end of March 1959, another successful financing step outside the UK took place. BP Refinery Canada Ltd. placed, through Canadian financial houses, $17 million of 5½% first-mortgage sinking-funds maturing 1979 at an issue price of 98½. The issue was secured on the assets of BP Refinery Canada, which include the plant under construction at Ville d'Anjou, and was guaranteed jointly by this company and the parent company. The issue terms provide for the establishment of a sinking fund to retire 75% of the principal amount of the bonds by March 31, 1978.

Several financing arrangements for new tankers have been made by BP since 1955. Early in 1957, the formation of Tanker Charter Co. Ltd. was announced. This company is raising £40 million of loans on the security of tankers recently completed, or under construction, to the order of BP Tanker Co. Tanker Charter Co. is purchasing these tankers on completion and chartering them back to BP Tanker Co. on terms calculated to cover loan interest and retirement at the end of 23 years.

In December 1958, the formation of a similar company—Clyde Charter Co. Ltd.—was announced, which is to finance £12 million worth of tankers being delivered this year.

A new jointly owned tanker company was formed at the beginning of 1959. This is Warwick Tanker Co. Ltd., a joint subsidiary of BP and Houlder Brothers & Co. Ltd. The new company will own two 35,000 dwt tankers due for delivery in 1960. They will be chartered to the BP Tanker Co.

Another joint tanker enterprise was formed early in 1958. This is Nordic Tankships I/S, a partnership between one of BP's Danish associates, A/S Tankskibsrederiet, and the East Asiatic Co. of Denmark. The partnership has acquired two UK-built 35,000 dwt tankers which are chartered to BP Tanker Co. END

100 YEARS OF OIL REFINING

HAROLD S. BELL, a Princeton graduate, organized H. S. Bell Inc., consulting petroleum engineers, after employment by Vacuum Oil (now Socony Mobil) and Sinclair. Designer of installations for construction in the USA, Europe, and North Africa, he also acted as officer in charge of British interests in Rome upon Italy's entrance into World War I. Appointed, in 1942, petroleum consultant to Board of Economic Warfare and later assigned to Army-Navy Joint Petroleum Board, he joined a mission to Australia to investigate oil shales.

Many of Mr. Bell's articles have appeared in the oil press. He is author of several published volumes on petroleum refining, transportation, and shale oils; and has made a study of the Russian oil industry.

by Harold S. Bell

The history of oil refining predates the past hundred years. In legendary times, oil from the Caspian area was distilled to produce a flammable spirit. In America, the oil obtained from salt-brine wells was first distilled by Samuel Kier, who established a one-barrel refinery in Pittsburgh in 1954. He introduced a distillate for illuminants with the trade name "carbon oil." His second still, with a capacity of 5 bbl, continued in use to the time of the first well drilled for petroleum, and some of the oil from that well was refined by Kier.

Prior to 1859, some 50 plants in the United States are reported to have been occupied with the crude distillation of coal. Following the pioneer efforts of Kier, several of them turned to "rock oil," or petroleum as skimmed from oil springs or obtained from salt-brine wells. These refineries followed the Scottish and English practice of the day.

The modern American petroleum industry may be said to have had its inception with the completion of the famous Drake well, August 27, 1859. Petroleum as first produced was generally termed "rock oil," and attracted the attention of scientific investigators. The report on this subject in 1855 by Professor Benjamin Silliman, Jr., of Yale University is still a classic of technical research. Silliman not only analyzed the oil for its various components, but predicted the commercial products which could be produced therefrom.

The Silliman report was made for a group of New England financiers, who were so impressed they incorporated the Pennsylvania Rock Oil Co. in September of 1855, of which the Seneca Oil Co. was later an outgrowth. The new PRO company had acquired title to farm lands in the vicinity of Titusville, Pa. It engaged Colonel Edwin L. Drake to examine its properties, and financed his experiment to drill a well for oil. On August 27, 1859, petroleum was discovered at the shallow depth of 69½ ft. With the arrival of "flow" oil what we regard as the modern petroleum industry was born.

The several small plants which refined both coal and petroleum from previously acquired sources changed their operation to use the new "flow" oil. These miniature refineries ranged in size from a few barrels a day to perhaps 100 b/d, and their objective was kerosine for lighting. This kerosine encountered many difficulties in its acceptance by the public. Without fractionation facilities, the light ends of the crude oil were often improperly separated from the burning oil. Lamp explosions were inevitable and frequent. Treatment of the products was primitive. The heavy ends and unsaturates caused lamps to smoke and wicks to carbonize.

Redistillation of the prime kerosine cut improved fractionation. Acid and caustic washes were applied, and gradually a satisfactory product evolved. During this period, however, gasoline had no market, and presented a disposal problem. Gasoline is reported to have been surreptitiously dumped at night into streams, where it floated on the surface of the water and at times ignited—resulting in disastrous fires.

Also during that period, the heavy ends of the crude received little attention. Lubricant demands for the economy of that day were insignificant; animal and vegetable oils sufficed.

During Pennsylvania's production boom, hundreds of these small refineries sprang into existence—most of them located adjacent to the oil wells. The original stills were vertical cylinders of a capacity of 50 bbl to 150 bbl, with gooseneck outlet leading to coils submerged in a water box. Operations were carried on in batches.

By 1870, many of the earlier problems connected with the marketing of petroleum

Ad, 1883 style, courtesy Standard of New Jersey.

Cleveland, O., June 15, 1883.

Dear Sir:

We desire to call your attention to our Mineral Seal 300° Fire Test Burning Oil, which has gained for itself so valuable a reputation both for its great illuminating powers -- giving a brilliant white flame-- and for its wonderful safety properties, being superior to all other burning oils in this respect, withstanding a heat of 300° Fah. before igniting, for which reason it is especially adapted for use in Railway Coaches and Passenger Steam Boats. It is now being extensively used for this purpose all over the United States and Canada.

Very Truly,

Standard Oil Company.

products had been overcome, placing many of the small refineries in an uneconomic position. With larger units required, horizontal cylindrical stills made their appearance. These stills were 6 ft to 8 ft in diameter, and 15 ft to 25 ft in length. Where natural gas was available from the wells, the stills were gas-fired; otherwise coal, and even wood, were used. Condensing equipment remained about the same; and, in primary distillation, no effort was made at fractionation. To obtain better products, the kerosine was redistilled in a second group of steam-heated stills.

Throughout this period, western Pennsylvania was the center of the oil industry. Not until years later was oil discovered in other states. Consequently, the refining industry settled in the producing area. In Pennsylvania, the towns of Warren, Titusville, Oil City, and Franklin were the principal centers for the growing industry.

Not all of the crude produced went to the local refineries. New refineries were established along the eastern seaboard, from New York harbor to Philadelphia. Cleveland, Ohio, the home of The Standard Oil Co., also became a refining center. Producers had quite a problem delivering oil to these new plants. Wooden tanks on flat cars were used until 1869, when the first horizontal cylindrical tank car of wrought iron appeared. During this period, rail transportation was not too reliable. Short interconnecting lines were the order of the day, and their labyrinth of interconnecting tariffs made through-routing a problem. The Empire Transportation Co., formed in 1865, helped remove some difficulties; it acted as intermediary between the railroads and furnished a supply of tank cars.

Some small pipelines had been installed in the early days, but these were limited in capacity—capable only of taking lease production to a central point. The first pipeline of any capacity or length was completed in 1879 from the Bradford field to Williamsport, Pa., where transfer was made for rail shipment to Philadelphia and New York. A few years later, the line was extended to Bayonne, N. J. Thus, crude oil became available to the refineries which were being established at centers of consumption, and where export facilities were available.

In 1885, production was established in Ohio. The Lima, Ohio, field was one of the principal areas, but its oil had a high percentage of sulfur and was of low value to the refiners who had no means of removing the objectionable compounds.

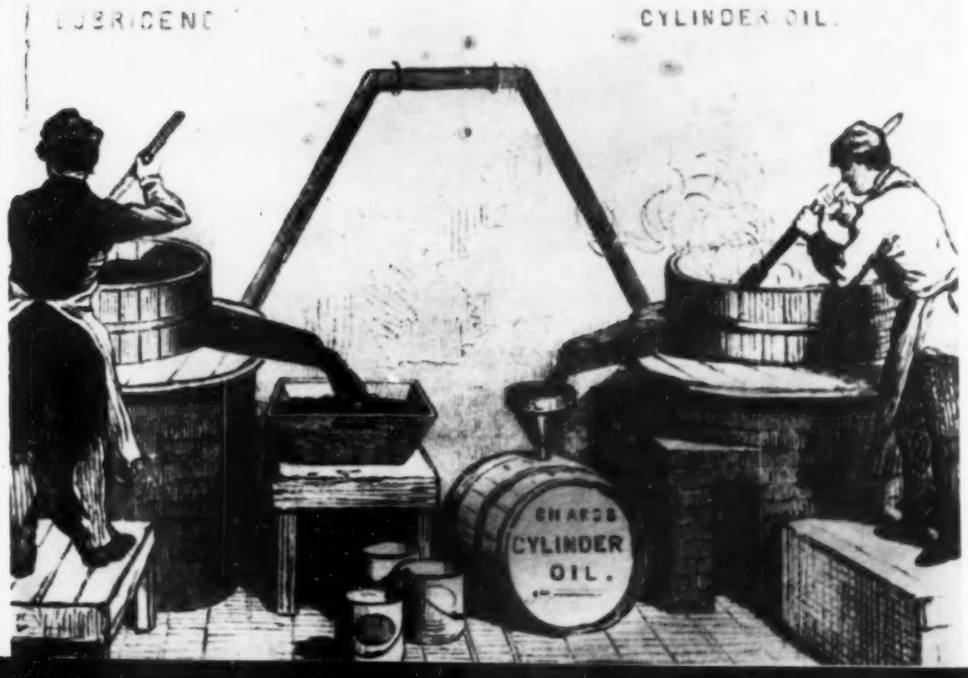
Similar problems were being experienced by the budding oil industry in Canada. The oil from the province of Ontario was also sulfurous. Herman Frasch, a noted European chemist, became interested. The process for removal of sulfur compounds which bears his name was successfully developed in 1885.

In 1888, the Frasch process was introduced to the United States; thus the problems inherent in refining of Lima crude were overcome. This process consisted in heating the burning-oil distillate over finely divided cupric oxide. In practice, a still of the cheesebox type was utilized in capacities of 1,200 bbl to 1,500 bbl. Drag chains were attached to an agitator frame from a central vertical gear-driven shaft. This process, as developed by The Standard Oil Co., led to the popularity of the cheesebox type still in the refineries of that period. All operations continued to be conducted on the batch principle, with no attempt at fractionation other than that from redistillation.

During the 19th century, oil technologists in the United States had little scientific literature to guide them. Much work had been done on the chemical analysis of oil, its constituents and products; but this information was widely scattered in various technical journals, and received little distribution. Consequently, the pioneers turned to some of the foreign publications. As examples, there are *PETROLEUM—A Treatise*, by Sir Boverton Redwood; *Das Erdoel*, of Engler-Hoffer; and the works of Gurwitsch, translated and revised by Moore. These volumes had an influence on early refining technique in the United States.

Following the development of the Appalachian oil fields, production was established in other localities. Petroleum is now produced in 38 of the states of the union. Refining followed.

Monitor refinery (above) on McClintock farm, Oil Creek, Pa., 1864.



Cooking oil one batch at a time: Cylinder oil was a heavy lubricant for machinery such as steam engines (photo, courtesy New York Public Library).

Oil was discovered in California in the 1870's, and the first refinery was established in 1876. Texas entered the picture in 1896. Spindletop, the first great American gusher, drilled in 1901, gave Texas a production lead which has never since been surpassed. As the oil regions of the Southwest were developed, the Gulf Coast became the No. 1 refinery center of the country, and it continues to hold that position today.

Prior to about 1905, refiners continued distillation by the batch method in cylindrical and cheesebox-type stills. The only technical advance was to increase the size of units, some of which charged as much as 1,500 bbl. From 1905 to 1915, refiners turned to continuous distillation by connecting six to eight cylindrical stills together—a method adopted from European practice of the day. By setting the stills at successively lower levels, or by adjusting the liquid level in each still at successively lower levels, usually 6 in. to 8 in., gravity flow was accomplished. Now heat exchange became practical. First residual exchangers of double pipe or coil-in-shell were used, and later crude vapor heat exchangers appeared. These innovations greatly improved the low thermal efficiency of the batch still. Capacities were increased, and somewhat better fractionation attained. The continuous battery became a standard installation in all but the smallest refineries. The method remained in use until the advent of the modern pipe still.

It is strange that fractional distillation received so little attention from early American refiners. Even in the 16th century, the ancient alchemists utilized crude towers with reflux and were capable of separating distillates into several components. True, the towers were crude and the fractions incompletely separated, but the principles, if not the scientific theories, were known.

The development of the fractionating tower in the United States is interesting. In an effort to reduce the amount of rerun, many early attempts were made towards better separation of the vapors. The early towers, so-called, which appeared about 1900, were the simplest kind of dephlegmators. Uninsulated vapor lines inclined back to the still—weird shapes which contracted and expanded the vapor stream such as Von Tilburg's tower, the Gray air-cooled tube bank—all had their day without enough success to pay for them.

In 1905, the packed tower was introduced for rerunning naphthas. This was the first improvement to utilize counterflow of descending condensate vs. rising vapors, with recognition of the laws of partial pressures. Refiners were on the right track. But the packed tower had disadvantages. With the diameters required for the volumes processed, it was impossible to attain even distribution over the cross-section, and the towers would channel. The next improvement was the baffle tower, wherein a series of baffle trays directed the liquid and vapors to more even counterflow. Then followed the perforated plate tower, which was successful so long as velocities were constant. It is interesting to note here that, with today's better knowledge of design, modified perforated plate towers are again receiving attention.

About 1920, fractional condensation was extensively tried. Again lack of knowledge of the laws of partial pressures was responsible for the meager success.

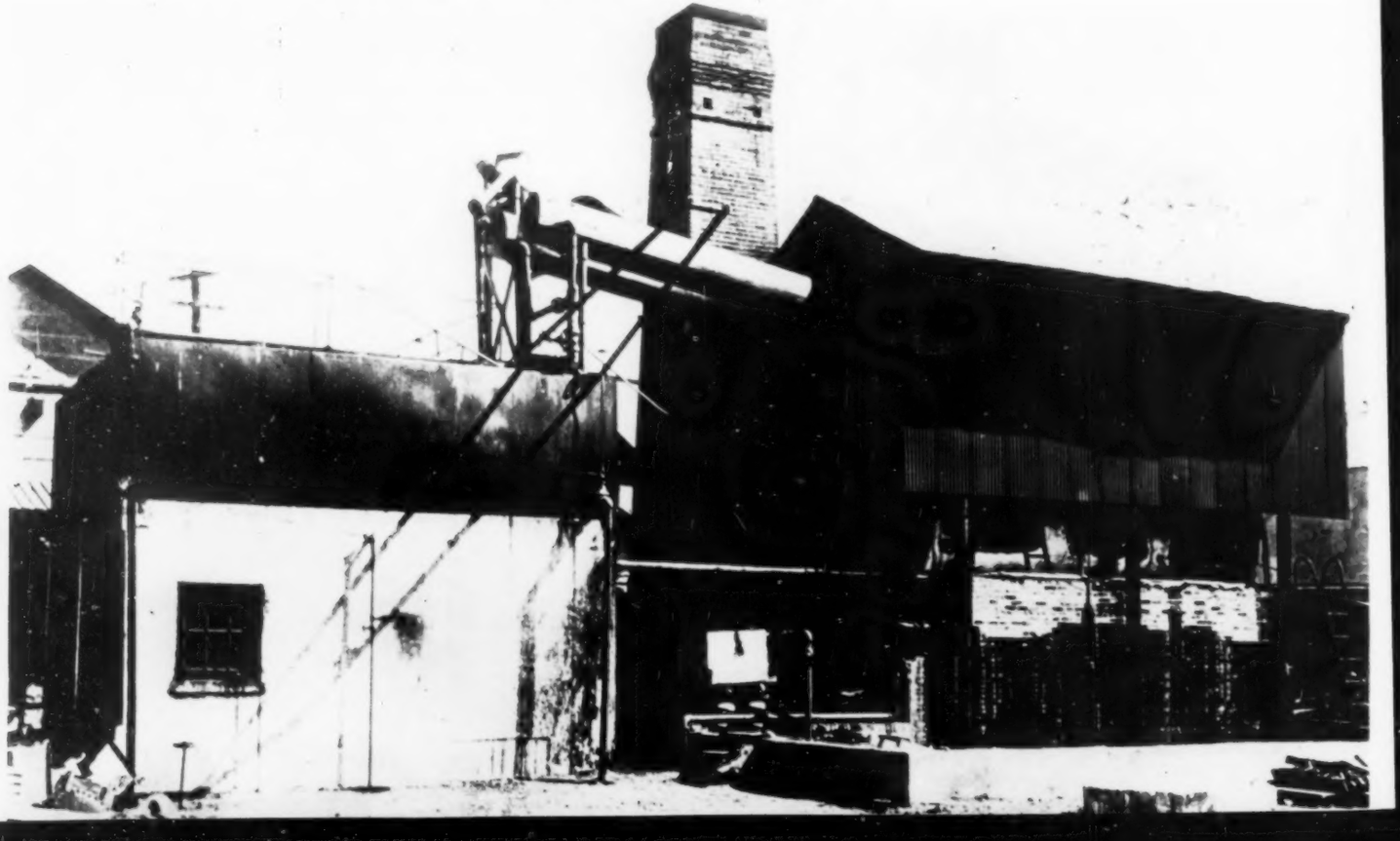
In the early years of the present century heavy Mexican crude came on the market. It contained a high percentage of salt in emulsion. The crude would foam and boil over in the conventional cylindrical still. This situation led to the introduction of the pipe heater to flash crude and water vapor prior to fractionation of the distillates. Dephlegmators and partial condensers were added, and the modern pipe or tube still came into being. M. J. Trumble began experimenting in 1909, and obtained patents in 1911 and 1913. He built the first such still at Fellows, Calif. in 1912. Improvements followed, and the system was extensively used on the West Coast by the Shell and General Petroleum companies. The units of that day were crude compared with modern distillation plants, but they attracted attention and led the way.

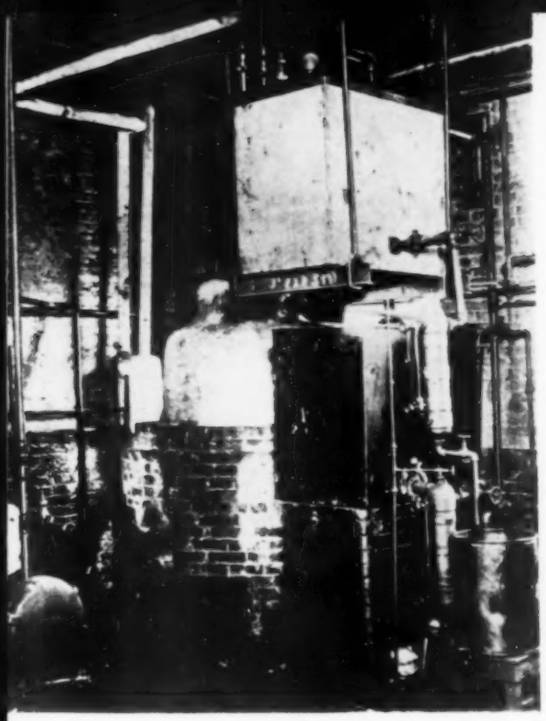
In 1918, the Foster Wheeler Corp. (then the Power Specialty Co.) installed a number of direct-fired tubular heaters for Sinclair's Isom cracking process; thus establishing the value of this type of heating.

But prejudice still had to be overcome as refiners adhered to their continuous batteries. Some refiners took advantage of tubular heaters by installing economizers in the flue gases from their continuous batteries. In 1920, the first direct-fired pipe heater was installed as a preheater for a continuous battery. The unit was merely designed to attain a temperature sufficient to flash off the gasoline fraction. Refiners feared coking and rupture of tubes, and also the possible cracking of their overhead lube distillates. Furthermore, the fractionating system necessary for a single flash had not as yet been developed.

In the '20's, the bubble-cap tower such as used in the chemical and alcohol industries began to receive refiners' attention. Here was a way to attain complete fraction-

First semi-commercial Burton-Humphreys cracking still at Indiana Standard's Whiting refinery, 1911-1912, established operating conditions for later full-scale units.





First experimental Burton-Humphreys cracking still, built in 1910 (Standard of Indiana photo)

ation of the wide range of distillates evolved in a single flash. It is believed the first modern tube still—complete with fractionating tower, residual and vapor exchangers, side-cut strippers, and control instruments—was installed at the plant of the Marland Oil Co. (now Continental), at Ponca City, Okla., in 1928. Foster-Wheeler Corp. was the designer and builder; and the latter had to guarantee the client that, if it did not perform to specification, the installation would be removed at no expense to the refiner. It worked.

Today the tube or pipe still is standard with the industry. It is used in all types of combinations—singly or in series, for atmospheric and vacuum service, for visbreaking, and in all thermal cracking processes.

About 1930, application of a dry vacuum to the fractionating tower was successfully developed. Here, the light ends of the crude are flashed off first, either by means of heat exchange or by use of a preliminary pipe heater. Because it reduced operating temperatures, this step overcame the objections of some refiners who feared the high coil outlet temperatures would affect their lube distillate and residuum lube stocks. It was now possible to produce satisfactory lube distillates and specification cylinder stocks and asphalts.

In these early days, oil refining was conducted haphazardly by rule-of-thumb. Refining "secrets" were guarded jealously. The stillman handed down his knowledge to his son or protegé, as did also the treater and other operating foremen. Not until the turn of the century were chemists employed, and their work was limited to laboratory testing of products—with instructions to keep their nose out of the refinery proper. But these pioneers persevered until their influence on processes started to be felt. Following the early chemists, some engineers began to be employed, but gradually. For example, one of the major oil companies of today did not employ its first graduate engineer until 1912; today it has in its employ several hundred.

World War I brought the refiners effectively together for the first time. Standard and Independent, major and minor, all cooperated in the war effort. An outgrowth of the committee work then undertaken by the industry is the American Petroleum Institute. Founded in 1919, the Institute was destined to assist materially in the scientific advancement of the industry. More progress has been made since that date than in the preceding 70 years of refining.

But the old secrecy concerning manufacturing was not dispelled quickly. Within the memory of one consultant, a client disclosed in great confidence an improvement, let us say, in a treating method for kerosine. The next day in another client's plant, not more than a mile away, the same "secret" was again disclosed confidentially.

Many will recall an early meeting of the smaller refiners. A young chemist stood up and pulled a one-dollar bill from his pocket. Turning to the man next to him, he asked if he had a dollar bill—upon its presentation, the young chemist then said: "Each of us has a dollar. We exchange. What do we each still have? One Dollar! Now I have an idea, and you have an idea. We exchange. What do we now have? Each of us has two ideas!" A lot of the reserve within that group broke down right there, and the National Petroleum Assn. from that date has been a leader in the dissemination of technical information valuable to all.

At the turn of the century, there were about 440 refineries. While many continued to be located in oil-producing areas, the trend was toward refinery sites in centers of population, and where marine transportation of products for export was feasible. The largest refinery of the time had a capacity of approximately 20,000 b d. The average plant refined 3,000 b d to 4,000 b d.

Technique had changed but little from early Oil Creek days. Larger units, however, had been introduced. Horizontal cylindrical stills attained a charging capacity of 1,000 bbl; treating agitators, 500 bbl. But batch operation continued standard practice.

The early years of the 20th century revolutionized transportation—with the automobile no longer a play thing. Long a product difficult to dispose of, gasoline now became of prime importance. How to meet the growing demand for motor fuel was the problem. The conventional yield from the volume of crude oil available was insufficient.

In the early 1900's, investigators were turning to "cracking." It was known in those days that the molecules in the heavier petroleum fractions would break down into a lighter and heavier molecule when subjected to high tempreratures. Years earlier, efforts to increase the yield of kerosine had led to many suggested processes and patents for this thermal reaction. Atwood (U.S.P. 28246) as early as 1860 offered a process operating at atmospheric pressure to attain increased yields of "burning oils." Benton, in 1886, proposed the first system in the United States to utilize pressure on the still.

Investigators in England were also active. Young, in 1865, proposed the first process for distilling under pressure. The Dewar-Redwood process in 1890 both distilled and condensed under pressure. None of this work was commercially successful, probably for two reasons: (1) The investigators did not realize the effect of the unsaturates formed in the reaction; and, as burning oil, the product was not satisfactory. (2) The materials of the day were not suitable for use at the higher temperatures and pressures.

As the demand for gasoline grew rapidly, refiners again turned to cracking. Many of the unsaturates, objectionable in kerosine, were acceptable in motor fuels. Better materials were available for construction of the plants. But the development still centered upon the use of direct-fired horizontal shell stills.

The first commercially successful cracking process in the United States was by Dr. William M. Burton, and was used by many of the Standard Oil companies. The first full-sized unit was constructed at Whiting, Ind., in 1912, and its success led to rapid commercial development. This system (original U.S. Patent 1,049,667) was modified and improved by further patents granted to Dr. Burton and others.

The original Burton process was carried out in a horizontal still 10 ft in diameter and 30 ft in length. It was operated on the batch principle at pressure of 75 psi to 100 psi, and at a temperature of about 740 F. The vapors were led at full still pressure through an inclined pipe—where some dephlegmation took place—to the final condenser. The charge was about 300 bbl, giving a 60% yield of pressure distillate and a final gasoline yield of 30% to 32% in a 48-hour cycle. To avoid overheating of still bottoms, the coke of decomposition had to be cleaned out after each run.

Later, Clark added front and rear headers, connected by fired tubes, to the Burton stills. The vessel proper was removed from the firing zone. The arrangement was similar to that of a water tube boiler. A dephlegmator was added, and the stills were operated semi-continuously by "feed in" during distillation.

Following the Burton process, several other systems attained commercial success in greater or lesser degree. Pressures of 90 psi to 125 psi were in vogue. At these pressures, the distillation temperature could be raised sufficiently to effect the reaction upon charging stocks then used. None of the processes attempted more than the most rudimentary fractionation. The light overhead product was termed "pressure distillate" or "synthetic crude," and was redistilled and treated for motor fuel.

The dangers inherent from bodies of oil subjected to high temperatures and pressures in direct-fired vessels were apparent. Short cycles and limited capacities were also a handicap to the early cracking plants.

The advent of heavy Mexican and California crude oils with appreciable water content led to the development of the tubular direct-fired heaters, as previously noted. Investigators turned to the application of pipe heaters for cracking, and the modern systems came into being.

Walter and Roy Cross utilized a pipe heater discharging to a reaction chamber at 800 F to 850 F, at about 600 psi. Their first commercial unit was built in 1921. A theory of the day was that it was necessary to hold the temperature over an interval of time, so-called "soaking," as accomplished by the reaction chamber. No separation of distillate and residuum was effected by the Cross process. The entire charge was condensed and cooled as a synthetic crude for further fractionation and refining.

At the same time, Carbon P. Dubbs combined a tubular heater, reaction chamber, and dephlegmator. Feed was introduced over the dephlegmator, thus effecting some degree of fractionation of the overhead light distillate. Pressures of 200 to 250 psi and coil outlet temperatures of 850 F to 900 F were employed. The Dubbs process was the forerunner of the many processes offered today by the Universal Oil Products Co.

In the years 1920 to 1930, several other processes utilizing pipe heaters, reaction chambers, and fractionating equipment appeared. Among them were the tube-and-tank of the Standard Oil Co., the Holmes-Manley of The Texas Co., and the Isom process of Sinclair Oil Co. Patent applications were numerous; allowed claims appeared in volume. Patent owners looked askance at one another. Suit followed suit. The innocent small refiner knew not where to turn. The richest harvest fell to the patent attorneys. By consolidation of companies, and by cross-licensing agreements and the expiration of many patent rights, the lines are now quite clearly drawn, and much simpler.

From the introduction of the Cross and Dubbs processes as representative of modern thermal cracking until the late '30's, improvements in the art included many refinements. Fractionation was introduced; recycling within the unit was practiced; heat exchange was applied; improved methods of coke removal were developed. The daily capacity of the thermal cracking plants was multiplied. The early Cross and Dubbs units processed 1,000 b/d—a big step forward from the Burton type stills of the day which ran only 100 b/d to 200 b/d. But by 1940, thermal units with daily capacities of 20,000 bbl were in use.

About 1936, attention of the industry turned to the application of catalysts to the cracking reaction. Much earlier, in 1919, the Gulf Oil Co. had installed a system, under patents to A. M. McAfee, which distilled oil in the presence of aluminum chloride. Upon successful tests, several units were installed by that company. Because of several operating handicaps, it was not generally accepted by refiners.

Tidewater's Bayonne, N.J., refinery about 1878.

The Houdry process was the pioneer catalytic cracking process to be adopted by American refiners. The first commercial units were installed by Sun Oil Co. in 1936. The early installations were of the fixed-bed type. Several reactors were employed, some being onstream while others were in the process of cleaning and regeneration. Molten salt served to cool the chamber during the regeneration period and furnish heat during the reaction period.

Socony-Vacuum experimented with the application of the Thermofor kilm for catalyst regeneration, and in 1941 constructed the first Thermofor catalytic cracking (TCC) unit. Here was the first continuous moving-bed process, the catalyst being withdrawn from the reactor and, by mechanical means and later by air lift, conveyed to the kiln, regenerated, and returned to the reactor. In later developments, TCC utilized synthetic bead catalysts instead of the natural ones.

In 1941, Standard Oil Development Co. installed the first "fluid flow" catalytic cracking plant. The process utilizes a finely divided catalyst maintained in a fluidized state, with flow properties similar to those of liquids. The catalyst moves from reactor to regenerator, and from regenerator back to the reactor—utilizing the gaslift principle of balancing a stream of high-solid density flowing downward against a stream of low-solid density flowing upward. Modern processes are of the last two general types. The moving-bed is exemplified by the TCC and Houdriflow processes. The fluid-flow system is exemplified by "fluid-flow," Orthoflow, and others.

Compare the first Burton stills of 100 b/d capacity with the modern fluid-flow cracking unit of Orthoflow design at Tidewater Oil Co.'s Delaware City refinery. This installation charges 58,000 b/d of fresh feed, and with 75% recycle has a total throughput of 101,800 b/sd.

The advent of World War II had a marked impetus on hydrocarbon research. The demand for high-knock-rating aviation fuels led to the development of many processes for the production of blending components to meet the specifications. Alkylation, reforming, polymerization, isomerization, and other methods all received attention. The reactions involved were recognized in the late '30's. Early efforts to apply the theory to commercial use by the thermal-pressure route were not too successful. The introduction of catalysis to the refining industry opened new vistas to the technologists. The modern refinery employs many, if not all, of these auxiliary processes.

At the turn of the century, motor fuel consisted of straight-run light distillate from crude oil. From 1910 to 1940, blends of straight-run and cracked gasolines with some natural gasoline (the casinghead gasoline of early days) fulfilled market requirements.

As the compression ratio of motor-car engines become higher and higher, search began for a suppressant for the ensuing knock. The first, and perhaps greatest, improvement came with the development of an additive, tetraethyl lead (TEL). Research on this compound, strangely enough, was done outside the oil industry. Thomas Midgley, Jr., of General Motors Corp., proved the effectiveness of TEL, and it was introduced to the oil-refining industry in 1923. Other additives to prevent gum formation, to retard rust formation, and to add certain favorable qualities appeared. Dyes came into use to identify grades and brands.

Today's product includes the above with the addition of alkylates, polymer gasoline, isomates, reformates, and three to five additives. In one of the most modern refineries, 10 different streams flow to the blending department where one to five additives are incorporated in the final product.

While the early American refiners were concentrating on kerosine production, Austrian and Russian oil companies were successfully promoting the use of mineral oils for lubricants. Previously, animal and

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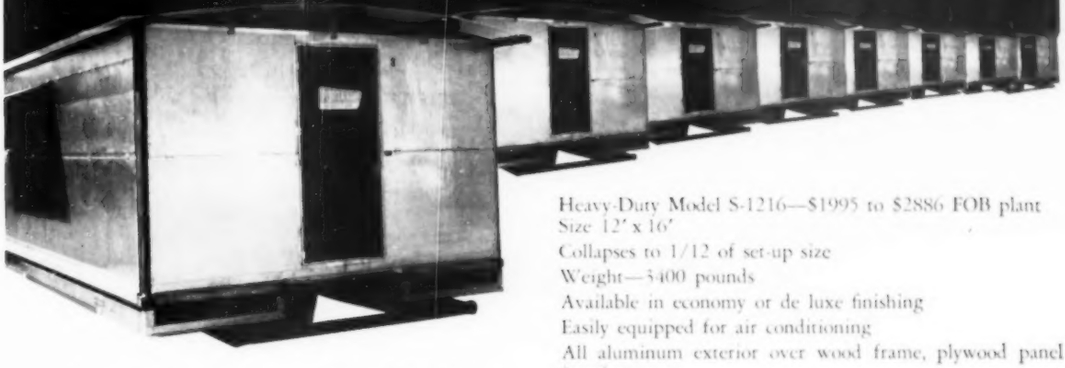


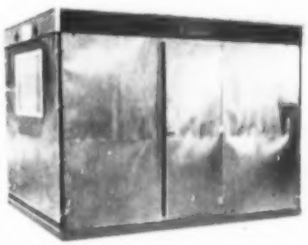
*Cost of completely equipping, crating, and dock-delivering a 50-man camp for shipment to Libya. Included were the new Model S-1216 units, all-electric kitchen, two mess halls, one 8' x 32' permanently-erected, steel skid-mounted bath and laundry, cots, mattresses, bedding, kitchen utensils and other required equipment.

This is another example of Porta-Kamp's ability to meet the field housing needs of operators all over the world.

Heavy-Duty Model S-1216—$1995 to $2886 FOB plant
Size 12' x 16'
Collapses to 1/12 of set-up size
Weight—3400 pounds
Available in economy or de luxe finishing
Easily equipped for air conditioning
All aluminum exterior over wood frame, plywood panel interior
Heavy-duty, knock-down construction
Steel skid-mounted
AIR-FLO Roof
New J-LOK (r) makes possible a positive wall-to-floor lock, quick set-up and ruggedness
Erected building may be moved intact or knocked down for space saving (available in 8' x 16' size)

PLUS—You benefit from an average saving of 80% on shipping costs when you buy Porta-Kamp buildings.

Lightweight Model D-1-C—$585 FOB plant Size 10' x 10'
• Shipping case size—40" x 10' x 14" • Weight—550 lbs.
• Also available in size 10' x 20', model 2D-1-C
• Costs less than tents—let us prove it! • Set up in 15 minutes.



Medium Weight Model K-10—$995 FOB plant Size 8' x 10'
• Fully insulated • Join several units together
• Available with AIR-FLO Roof
• Weight—950 lbs. • Shipping case size—8' x 10' x 15"

*If you are interested in lighter weight, a 50-man fly camp, fully equipped can be purchased and dock-delivered for $15,000. This includes the Model D-1-C units, kitchen, mess hall, cots, mattresses, bedding and all necessary living equipment.

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Complete camp outfitting • Expert crating and packaging

Porta-Kamp Manufacturing Co., Inc.
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in only 8 months at 10 per cent under budget

10% UNDER BUDGET—Pennsalt Chemicals Corporation's new Methylamines plant was completed by Catalytic, Engineers—Constructors, at a figure ten per cent under the original estimated cost.

AHEAD OF SCHEDULE—The Methylamines plant was completed and ready for start-up in only eight months after the start of engineering. This "On-Time" completion was in advance of the requirements of Pennsalt Chemicals Corporation.

UNDIVIDED RESPONSIBILITY—Catalytic's control and coordination of all phases of this project and close cooperation with the client were prime factors in the successful completion. This Methylamines plant again proved Catalytic's ability to render all client services "On-Time, On-Budget".

CATALYTIC
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Philadelphia 2, Pennsylvania
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Catalytic *On-Time . . . On-Budget* Services for the metallurgical, chemical, petrochemical and oil refining industries: Project Analysis; Process Development; Process Design; Economic Studies; Engineering; Procurement; Construction.

Refinery at Petroleum Center, Pa., in 1864.

vegetable oils had fulfilled the needs of the rather limited demands. Power was generated by steam engines, and machines were of simple design. The internal-combustion engine, the steam turbine, and high-speed machines were nonexistent.

In the United States, about 1880, refiners first turned their attention to the production of stream cylinder oils to meet the growing demand for power. The technique was quite simple. The Pennsylvania-grade crude oil then available was paraffin-base. Simple reduction to proper fire and flash tests in batch stills produced a residual product satisfactory for the purpose. To assist distillation and maintain temperatures sufficiently low to avoid excessive cracking, stream was injected into the body of the oil through open spray pipes along the bottom of the still. The theory as to the resulting partial pressures was not generally appreciated, and the steam was supposed to help "carry over" the distillates.

The production of the "stream-refined stock" resulted in a considerable fraction of distillates containing other valuable lubricants, and attention was directed toward their development. During this period (1875-1885) the Scotch shale-oil industry was making progress in the manufacture of waxes from the middle distillates of crude shale oil. The distillates were not acceptable for lube manufacture because of the excessive cracking in the shale retorts. Since the paraffin distillate from the Pennsylvania crude had to be dewaxed before use as a lubricant, the American refiners adopted the equipment of the Scotch shale industry. The plate filter press and the Henderson wax-sweating ovens appeared in United States refineries about 1880. The distillate was chilled, pumped through the presses at high pressure, and at the right temperature, to control the cold test of the pressed oil. The wax cake retained in the presses was sweated to remove entrained oil and produce a wax cake of suitable melting point.

This technique opened a new field to refiners. A complete line of machine lubricants was now available, and by 1890 had absorbed the market for this line of products. The specifications of the period were vague. Viscosity, flash, fire, and cold tests were gradually introduced—and instruments, still in use, were devised for control.

Demands of the trade and competition hastened improvement of the product. Acid treatment and caustic neutralization, long used for kerosine, were applied to distillate lubricating fractions in the early days of their introduction to the American public. Color became a strong selling point for spindle and machine oils, and in 1890 filtration through bone char was introduced. Later, fuller's earth supplanted the use of bone char.

Like all processes of the period, the operation was conducted in batches. As a filter went "off color," it was drained and steamed. The clay was revivified in primitive gravity-type burners which removed the tarry adsorbed coloring bodies and opened up the pores of the clay, which was then reintroduced into a waiting filter. After four to six cycles, the clay was discarded. The general method, with improvements, is still in use.

Efforts to prolong the life of the filtering medium were sought. Temperature control during revivification was most important, and improvements in burning directly followed better control. In 1915, the rotary kiln, as used in the cement industry, was introduced. This was followed in the early '20's by adoption of the multiple-hearth furnaces of the Herreschof and Wedge types as used in the mining industries. The Thermofor kiln was developed in 1935 by Socony-Vacuum Oil Co., and has greatly increased the efficiency and life of the filter clay.

Starting with the six burns obtainable with the early gravity kilns, the number was raised to 10 in the rotaries, to 25 to 30 in the multiple-hearth furnaces, and there are reports of a hundred successful regenerations with the Thermofor kiln.

Efforts were constantly being made to improve filtering operations looking toward continuous operation. Success was finally obtained in 1952 by Socony-Mobil Oil Co. The clay is constantly withdrawn from the filter, washed, passed through a Thermofor kiln, and returned to the filter. Thus, while the fundamentals of the filtration process have remained the same over 70 years, great advances have been made in the application of the techniques.

The advent of oil-producing fields in states other than Pennsylvania, and the increasing lubricant demand, necessitated the production of lubricants from other than paraffin-base crude oils. Before the development of solvent processes, these lubricants were heavily acid-treated. Neutralization of the acid oils was a serious problem. Emulsions, difficult to break, often occurred. Time wasted in setting gave trouble. It was found that the tarry matter left in the oils could be adsorbed by finely divided fuller's earth. Since the oil still had to be brought to color by filtration, here was an opportunity to "kill two birds with one stone," and the contact method of filtration was introduced in 1923. The term "filtration" appears to be a misnomer, as the process is in no way filtration within the usual interpretation of that word.

In practice, the finely divided clay, 200-mesh, is introduced into the heated oil, dry or as a slurry. The mixture passes through a pipe heater, and is raised to 400 F to 600 F; thence it goes to a flash drum where steam and any light vapors are removed; thence to a cooler, followed by a filter of the Sweetland or rotary type where the clay is removed. The filtrate is usually then passed through a blotter press to catch any remaining traces of clay. The clay is naphtha-washed and steamed to recover any remaining lubes, and is then discarded. Ex-

cept for refinements, there has been little change in the process since its introduction.

The advantages of the contact system are low first cost of installation and its adaptability to an acid-treated oil. Its disadvantage is in high cost of operation due principally to the high cost of the clays, many of which are especially prepared products used once and discarded. The disposal of the spent clay is also a problem.

The impact of the rapidly growing automotive industry not only spurred the production of motor fuels, but created a demand for more and better lubricants. One requirement was for a heavier, more viscous, low cold-test, wax-free blending stock. Straight steam-refined cylinder stock was not acceptable. The amorphous wax presented a problem. As early as 1895, legend has it one Pennsylvania refiner by chance stored crude in tankage exposed to the weather over the winter months. He found a layer of amorphous wax in his tank, and the resulting cylinder stock from the crude had a lower cold test and much brighter appearance. For several years this practice was followed, with premium prices for the "bright stock."

As demand grew, artificial means were developed to attain the result. The residual cylinder stock was placed in solution with naphtha and transferred to well-insulated tanks. Here it was slowly chilled by top brine coils, with consequent separation of the wax from the mixture. The specifications of the "bright stock" were now subject to close control. This batch method continued until the introduction of the centrifuge to effect the separation.

Centrifugal separation of solids from liquids had been practiced for several years. Further development led to the separation of "cream from milk." The separation of the amorphous wax from residual stocks was studied for several years. The continuous discharge of the wax from the rotor was the problem—finally to be overcome by the Sharples Corp. by the introduction of warm water as a carrier liquid. The first commercial plant was installed in 1920. This advance in technology gave a closely controlled product of 20 F or less cold test as compared with about 50 F for good cold settlers of the batch tank type. Many installations were made throughout the industry, and a number are still operating.

The original Sharples process was not suitable for charging stocks containing any crystalline wax. In 1934, the Sharples Corp. introduced the Barisol process, wherein a mixture of benzol and ethylene dichloride was substituted for the naphtha as a solvent. This improvement permitted long residuums and distillates to be dewaxed. The first commercial installation was in 1934.

In Europe, centrifugal processes for wax removal were installed by DeLaval Separator-Nobel.

The filter press for distillates and centrifuges for residuums continued to be the conventional methods of wax removal until the advent of solvent dewaxing. The first plant of this type was developed by The Texas Co., and installed at the Lawrenceville, Ill., refinery in 1928. Originally using a mixture of acetone and benzol, it was often termed the acetone-benzol process. The solvents used are not confined to the above and a variety may be used. In 1934, a mixture of methylethyl ketone was introduced as a solvent, and the system is now generally termed MEK dewaxing.

The process has a lower first cost than the older conventional installations, and possesses features of close control and flexibility. It is in general use today.

1910 saw the first application of solvents for lube-oil purification. The Edeleanu process using liquid sulfur dioxide was introduced in Romania. Originally intended for the desulfurization of kerosine, it was adopted by many European refiners and modified for use on lube stocks. American refiners were slow to accept it, and nearly 20 years elapsed before the first USA installation. By that time, other and simpler solvent processes were under development, to which American refiners turned.

By 1930, several processes became available to the refiner. Propane, furfural, phenol, chlorex, and cresylic acid are in use as solvents. Some processes use two of these products. Duosol, for example, utilizes both propane and cresylic acid. With the introduction of solvent-extraction processes, sulfuric-acid treatment of lubricants has greatly diminished.

One of the phenomena of the growth of the American refining industry is use of progressive larger units. In the era immediately following the Drake well, the average daily capacity of a refinery approximated 150 bbl. By 1900, some refiners were processing as much as 20,000 b/d, and the average was perhaps 2,000 b/d. During the succeeding period to World War I, there was growth in size of individual units and a reduction in the number of plants. Refineries having capacities to 50,000 b/d were in operation. The trend continued until about 1950, when many oil companies realized their capacity was concentrated too much in large refineries; they constructed smaller plants at locations where transportation was favorable and consumption was growing. By this time, the capacity of a few refineries had approached a figure of 400,000 b/d.

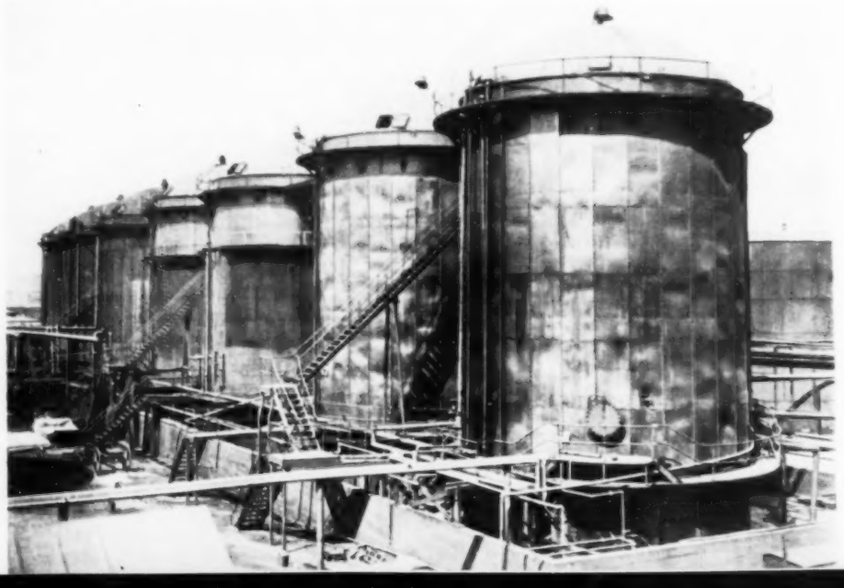
A survey made in 1951 disclosed 331 refineries in the United States. Taking a median line of 30,000 b/d capacity, 82% were smaller and 18% larger. But the 82% represented only 29% of total refining capacity of the country.

Refining in Europe may be termed both the oldest and the latest oil development—oldest because of the Romanian and Russian refineries, contemporaries of the early days of the American petroleum industry. Until well after 1900, refining of petroleum centered in Russia, Romania, Germany, Austria, and Poland. America owes much of its early technique to these European refiners.

With the discovery of new fields in Iraq, Iran, Venezuela, and Saudi Arabia, economics favored new refineries far removed from the previous sources of crude oil. The two world wars, with ensuing currency restrictions and a growing spirit of economic independence, favored the growth of the industry in many lands. The world total of daily refining capacity stands today at 20 million barrels, exclusive of the USSR—with 50% located in the United States. The United Kingdom, Canada, Venezuela, Italy, France, Japan, and Iran follow in the order named.

And, so, we may summarize: The first 50 years of oil refining saw little technicological change from the small primitive batch still of 1860, except that units increased in size and continuous running offered opportunities for heat exchange. In the period from 1910 to 1940, thermal cracking and good fractionation improved operations. Vacuum distillation, centrifugal and solvent dewaxing, and solvent extraction for lubricants appeared. Since 1940, catalytic cracking, and the auxiliary catalytic processes for the improvement of motor fuels and the synthesis of hydrocarbons for the manufacture of many chemicals, have all been adopted. From a technical standpoint, it is safe to say that the past 20 years have seen more advance than the entire preceding 80 years of the refining industry. END

Agitators at a Bayonne, N.J., refinery about 1915-1920 (SONJ photo).



60 Years of Oil-Field Experience

by A. Beeby-Thompson

My advent into the oil industry was absolutely fortuitous, and resulted from the offer of a position in 1898 as engineer for an English oil company operating in the Baku oil fields of Russia. The company was one of several early acquisitions by British financiers of prolific oil properties erroneously believed by their owners to have passed its best period. As there were few, if any, British subjects with practical experience of oil-field duties, reliance had initially to be placed on local personnel who were suspected of paying greater attention to the emoluments of their own friends and relatives than the earning of profits for a foreign corporation. On arrival, I was accepted by those in charge of field operations as a necessary evil—too ignorant to prove a menace—and, therefore, afforded facilities for mixing with the staff, gaining a smattering of the language, and acquiring some knowledge about oil-field technique.

I was not ill-fitted for the post, having been trained as a mechanical engineer in the hard way by apprenticeship for five long years and passage through machine shops and drawing office, with contemporaneous education in natural sciences such as geology, chemistry, physics, and mathematics. On release from five years of serfdom with hard taskmasters, I had secured a position with a firm of waterworks engineers where I gained experience in boring methods and pumping machinery, and it was this knowledge and an inherited desire for travel and adventure which led me to accept a government post in West Africa on water investigations. I miraculously survived two tours of eight months on the "White Man's Grave" where I learned the art of self-reliance and the value of improvisation in a country where one had to depend exclusively upon local resources for every job when in trouble, and work with Africans speaking strange lingos and totally inexperienced in handling any form of mechanical appliance.

My first glimpse of an untidy oil field caused astonishment, for single plots of a few acres were so cluttered with oil-soaked wooden derricks and sheds, plus other paraphernalia, that movements of men and materials were encumbered. Matters were worsened by oil spray from intermittent gushers and that from the whirling overhead pulleys of bailing wells which had soaked ground already rendered treacherous by the piles of oily sand removed from a confusion of wooden settling vats and chutes which conveyed the raised oil to collecting points.

Only by degrees did I come to realize that a kindly fate had led me to the richest oil field in the world, where a few square miles of terrain around the city of Baku were producing half the world's output of oil. More surprising was the discovery that single gushers striking virgin sands not infrequently yielding daily, for months, more oil than whole fields of large extent elsewhere. Flush yields of 70,000 b d to 100,000 b d for weeks on end were not uncommon in the early '90's, and the collection and storage of such formidable quantities of oil drove producers to adopt all kinds of unusual and speedy expedients for its accommodation, and that of the accompanying sand equivalent to about one ton per ton of oil.

A. BEEBY-THOMPSON, OBE, noted British geologist and engineer, is renowned for his pioneering efforts on behalf of the world oil industry, which owes him a great debt. He has been a frequent visitor and lecturer in the United States, where his friends are legion. We are grateful that in this oil-centennial year he should contribute something from his vast fund of early pioneering experiences, though to recount them adequately would take a large volume.

Both drilling and producing methods struck me as archaic and savoring of mediocrity before I learned that the penetration of unconsolidated, fragile, heaving, or swelling clays and running sands forced the use of large-diameter linings with frequent reductions of size where each column could be carried no deeper than a few hundred feet. I also learned that welded casing with screwed joints was then unprocurable, and that recourse was made to riveted stovepipe linings made in 7-ft lengths. Drilling was performed by a cumbersome free-fall system powered by steam engines through the medium of a noisy geared frame of rough construction. By the employment of these crude machines, drilling rates of about 7 ft per day were attained, and a projected 1,000-ft to 1,500-ft well called for an initial diameter of 30 in. to 36 in., and the use of five to seven strings to reach a worthwhile final size of casing; and so frequent were fishing operations for lost or broken tools that a year or two was occupied in drilling a well which could be performed in a few days or weeks with modern equipment.

Production by bailing imposed no less exasperating troubles; yet the method was enforced by the large amount of sand which accompanied the oil which, unless removed, choked the wells. In fact, bailing had been reduced to a fine art by long experience, for the presence of indigenous or imperfectedly excluded upper waters and the settlement of sand necessitated a delicate balance of top and bottom abstractions to insure a safe maximum rate of oil withdrawals. Deflected or crushed casing due to earth movements was so frequent that unusual practices, such as jointed or flexible bailers, had to be constructed to pass constricted or deflected sections of holes.

Despite the handicaps foreseen, I very soon mentally resolved upon many innovations when I was given authority, for daily contact with all phases of operations led me to visualize many changes which would result in economy and efficiency. The sudden death of the Russian executive manager soon after my arrival was used by London as a pretext for advancing my position, and I was instructed to report weekly to London on the condition of all drilling and producing wells. This exacting injunction not only compelled acquaintance with everything which was proceeding, but drove me to seek logical explanations for the anomalous behavior of productive wells and to suggest remedies for meeting mysterious inconsistencies. An oil-field manager's life, I discovered, was no sinecure, and enjoined day and night vigilance to meet exigencies. Nothing, in fact, escaped my notice, and I thereby acquired experience in handling fishing jobs, dealing with unexpected gushers, and tackling devastating fires—which latter in less than one hour would destroy several dozens or scores of derricks. From these and other difficulties which confronted a field manager, I gained much experience.

Oil-field management in Baku was complicated in Tsarist days by other factors—which included 40 prescribed official holidays each year to commemorate saints or the birthdays of royal personages in addition to Sundays. Although not forced upon oil-field workers, who drew double pay on those occasions, clerical work was disorganized. Further complications arose from the customs, religions, and behavior of the

Congested Yenangyaung field in Burma in 1921.

differing races engaged for various duties which suited their temperament. Considerable tact was necessary to sustain peace between the robust, thriftless, hard-working, heavy-drinking Russians, and the sober, thrifty, intellectual but insincere Armenians and Jews whose occupations were as machinists, mechanics, or clerks. Hot-blooded, fierce Caucasian tribesmen were disposed at the slightest provocation, after a few drinks, to attack with lethal weapons, in contrast with the more patient Moslems and Tartars who lived a frugal existence, practicing a religion which compelled suspension of duties at inconvenient times for prayers, whatever the nature of their occupation. The gift of a few bottles of vodka dispensed to Russians engaged on emergency duties would do more to hasten progress than any offers of money.

In the popular belief that oil was inexhaustable, little thought was given to geology or such ideas as depletion, gas conservation, fuel consumption, and orderliness —an attitude encouraged by the absence of markets for all light products. Kerosine (lamp oil) and fuel oil (artatki) were almost the sole objectives of refiners, and light distillates were burned to remove a dangerous nuisance. Prices of crude fluctuated rather wildly with output, but were closely related to those of other fuels such as coal, wood, or peat. Within a period of months, crude-oil prices sometimes varied several hundred percent between 30¢ and 70¢ per barrel for the prevailing high-grade nonparaffinous oils.

The Apsheron peninsula, I found to my delight after some regional excursions, provided a unique nursery for the oil geologist; for, beyond the limit of development, the oil-bearing series of strata was exposed in outcrops along valleys devoid of vegetation or overburden due to aridity. In the company of the only other British geologist in Baku, hours would be spent examining sections, associated with which was an unbelieveable display of live seepages, gas exudations, mud volcanoes—some of immense size—asphalt deposits and the like. Here could be witnessed, in textbook form, on scarps the influence of faults and the character and lenticularity of oil sands upon the distribution of petroleum in the stratified formations.

Assisted and supported by a famous R. E. engineer on the board, I was entrusted with the introduction of many novel devices which aimed at economy in fuel consumption and efficiency in operation, of which by far the most important was air-lift. Totally ignorant of its previous application to oil recovery, it appeared to offer so many possible advantages over bailing that the necessary plant was dispatched and duly erected. For experimentation, I was grudgingly permitted to use a small-diameter well where, due to water and sand infiltration and curvature, oil production had dwindled to 60 b/d; yet the static fluid level was high. Piping was arranged for the abstraction of fluid from the foot of the well with means provided for lifting and lowering the combination of tubing should the inlet become plugged with infiltrating sand. The results were staggering, for straightway production rose five times, to 300 b/d from 60 b/d, without any objectional results. This initial experiment aroused immense interest, and was witnessed by government officials and the many others responsible for oil production. All were convinced of its merits, and it led to immediate adoption on a large scale by major companies, and to astounding augmentations of output with the disappearance of bailing apparatus and operators. Subsequent employment in more suitable wells of greater productive capacity with the necessary static level led to spectacular yields as high as 1,500 b/d, representing in some cases 12 times that obtained by bailing the same wells. A 70-hp Hornsby Ackroyd oil engine was another innovation which proved its value as an economic source of energy—the largest then made and the first introduced into the Russian oil fields. An automatic instrument which recorded every movement of the bailing drum with the time was regarded by the operators as an invention of the devil.

A desire for wider experience and the first appearance of labor disorders induced me, in 1904, to return to London with a determination to open an office as an oilfield consultant. This decision was reached from the conviction that a great future awaited the petroleum industry in consequence of the rapid development of a reliable internal-combustion engine. Very fortunately, the timing synchronized with the growing popularity of petroleum search as a profitable outlet for capital, based on the remarkable success of some USA oil companies. I invited a highly qualified engineer, Campbell Hunter with Baku experience, to join me, a happy combination of optimism and prudence it proved! Rather to my surprise, compilation of Russian data upon which I had embarked for some time was readily accepted for publication on submission to Messrs. Crosby Lockwood, a leading publisher of technical literature. The appearance of this volume in attractive form certainly proved a valuable introduction to the city of London, and favorable reviews led to immediate approaches by several clients none too happy about their oil investments or entertaining the acquisition of foreign oil properties.

The successful fulfilment of several missions to Russia and Romania, and the writing of a few informative articles for journals on petroleum matters, served to attract attention to the young firm; but the first really important commission accepted was from the senior partner of one of London's most renowned merchant houses. Having perused my book, he concluded that I knew something about oil-field work and might be helpful to him in deciding the future of an immense oil concession in Peru which had long been a profitless drain on his purse. The sequel to this interview was a life-long friendship and the resuscitation under the firm's guidance of a moribund oil property to one of great prosperity which, after his death, continued unabated in the hands of a Standard Oil subsidiary company which acquired the concession and still works the property. The prestige gained from this connection and the sound advice our client invariably tendered concerning the ethics of business were a great inspiration to youthful city entrants.

The other event which enhanced our prestige in the city of London was the successful development of petroleum in Trinidad which followed a personal conviction that this island of sugar and cocoa plantations warranted serious oil exploration. Acquainted with the anxiety of the

Clearing the jungle in Trinidad in 1906, prior to drilling.

A camp at Abu Durbar in Sinai Desert, Egypt, about 1917, with oil-saturated sedimentary strata in background.

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British government to secure supplies of oil in territory within its jurisdiction, I succeeded in inducing an influential group who, mainly from patriotic motives, were willing to provide funds for the task. The terrain I was able to acquire by purchase from planters, or by lease from the sympathetic Trinidad government, proved eventually to be some of the most prolific in the island, and continued to be so until deep drilling disclosed more prolific sources elsewhere. No one in Trinidad at that time had the faintest inkling that oil production would become the most valuable asset of the island and eventually constitute its most important source of revenue with a production which rose to over 35 million barrels in 1958. In 1956, the oil industry disbursed $106 million and contributed $32 million revenue to the State. Through these and other notable achievements, the firm gained a reputation for integrity and sound judgment in business circles; and when, in 1908, the great mining corporations and professional promotors entered the petroleum arena, we were literally deluged with requests for reports on propositions in many parts of the world.

This sudden change of policy was unquestionably stimulated by the decision of Herbert Hoover, a distinguished USA mining engineer, intimately associated with the leading British mining finance houses, who regarded petroleum as a promising source of profit for addition to their portfolios of investment. With Herbert Hoover, I established a lasting friendship; and, largely through his influence and reputation, we were brought in personal contact with some of the most astute and discriminating financiers of London when every interview with these magnates was a source of pleasurable education and enlightenment. As few mining engineers had any knowledge of oilfield techinque, our help was sought on such questions as finance; drafting of prospectuses for public solicitation of funds; preparation of deeds, licenses, leases, covenants, and the like—indeed, almost implicit and unfair trust was placed in our judgment and decisions. These duties led, in turn, to other responsibilities; for we were expected to meet and satisfy brokers, bankers, underwriters, lawyers, and prospective directors concerning the validity of our statements and estimates in prospectuses before they would agree to their connection with new companies.

How I survived those hectic days of day-and-night work, and at the same time contrived to deliver lectures, address public bodies, write press articles, etc., is a mystery which the enthusiasm of youth and health alone may explain. However, a competent staff has been gradually collected with the help of British universities and technical colleges, and I was thereby relieved of much technical work such as the preparation of estimates, plant specifications and inspections, etc. Somehow I managed to supervise the issue of a second edition of the *Oilfields of Russia*, and even to write in 1909 a second book entitled *Petroleum Mining*. The whole edition of this latter volume was so quickly sold that I was constrained to produce in 1912 a volume entitled *Oilfield Development & Oilfield Exploration*, later revised on exhaustion of the edition yet another volume with the title *Oilfield Exploration & Development*.

Prior to the outbreak of World War I in 1914, investigations of oil prospects had been undertaken and reports made in such widely scattered places as Central Asia Angola, Madagascar, Argentine, Venezuela, Mexico, Bolivia, Honduras, Colombia, Burma, West Africa, East Indies, Spain, Portugal, Germany, and France. These were in addition to repeated routine visits to the European oil fields of Romania, Galicia, West Germany, and to Peru and Trinidad, as well as to many parts of the USA and Canada.

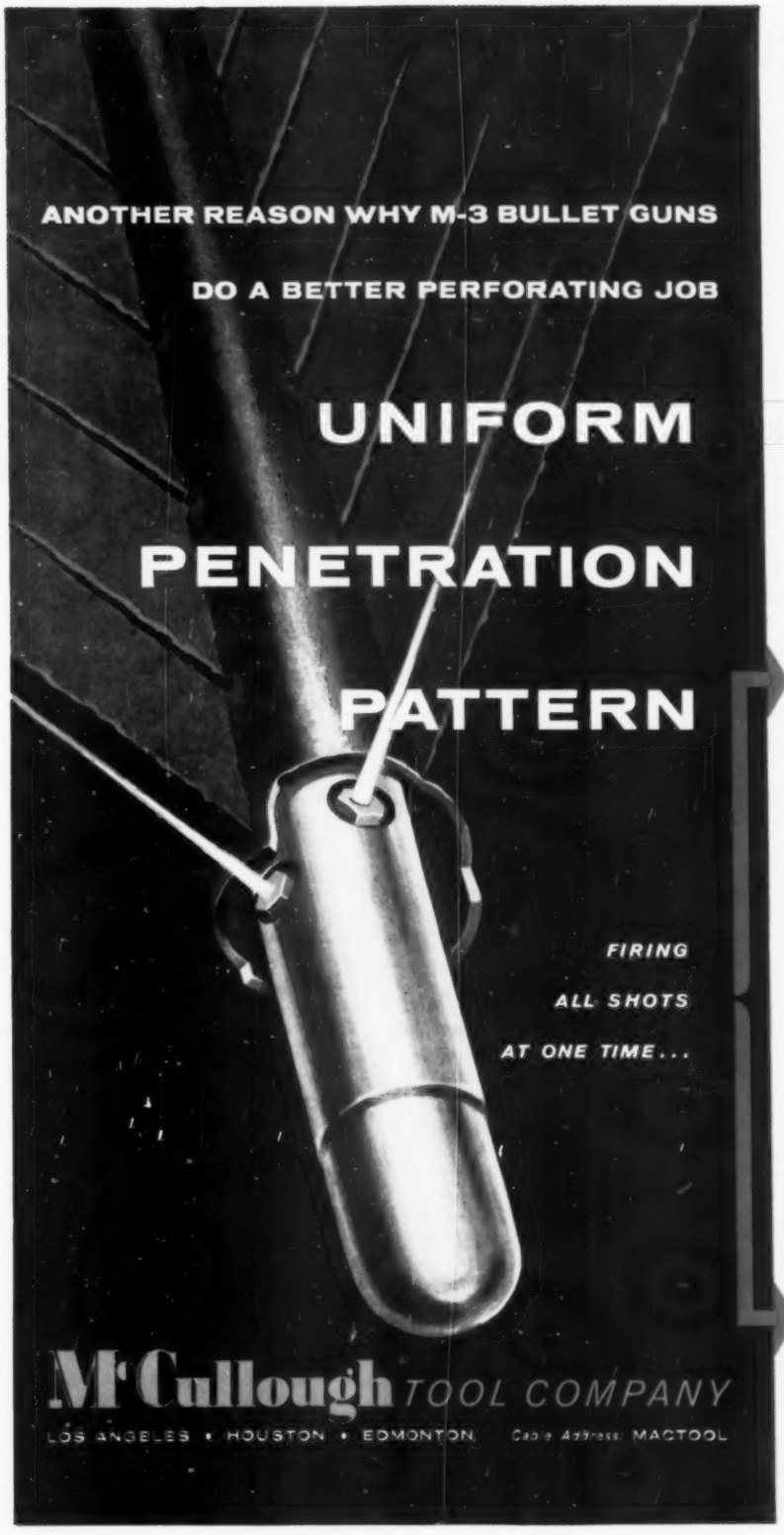
During the five years of warfare, I was engaged on war services; and, for most of the period, I was employed on military duties in the Middle East, with several breaks on important government missions. Operations in the Trinidad and Burma oil fields were intensified to assist the war effort when the onus of supplying fuel for the British armies and navy was placed mainly on the USA and Mexico. Shortage of essential materials was the main impediment to oil-field expansion, as military and naval demands had priority over all else.

The war had clearly demonstrated to what extent victory depended upon oil supplies for land, sea, and air services operating under extremely varied and difficult topographical and meteorological conditions. It was, consequently, not surprising that a worldwide scramble for potential oilfield terrain should develop, notwithstanding the scarcity of available equipment and skilled personnel for restoring war-damaged fields and expanding operations in established fields.

Considerable difficulty was found in meeting the inordinate demands for overseas exploration parties and securing skilled help for resuscitating destroyed works—further complicated by calls on my personal services for hydrological investigations in British colonies and dependencies. These latter resulted from the outstanding success of quick and cheap methods I had introduced for developing ground-water supplies in the war zone of the Middle East. The publication of *Emergency Water Supplies* describing my wartime experiences in this field served to attract widespread attention in underdeveloped countries where water was scarce. Among other noteworthy postwar changes was the transfer of the Hoover group of Trinidad, Peruvian, and Russian oil properties to other hands, and Mr. Hoover's entrance into politics first as USA Secretary of Commerce and later as President. The sequestration of all foreign-owned property in Russia as a sequel to the revolution was a disturbing factor in oildom, which compelled concentrated effort in other directions. Romania, in particular, was the objective of much attention from both European and American oil men; and it was in the fields of this country, after obstruction from unexpected quarters, that I secured the admittance of the first mud-flush rotary, applied the earliest chokes to flowing wells, initiated the first gas-gasoline installation, and introduced successful air-lift. Within a few months of proving their utility, they all came into popular usage. Drilling speeds with American rotary drills and operators rose from a few meters to a thousand or more feet a day; chokes led to an immediate reduction in blowouts and wild wells, besides reducing the damaging effects of sand expulsion both above and below ground. Air-gas lift in the first experimental Concordia well led to an enormous increase in output without incurring any of the predicted untoward consequences, and became a recognized and popular method of abstraction where conditions favored its application. Gas gasoline compression annd absorption plants came gradually into use.

Only once did I become embroiled with international politics, and that was in 1921 when I rather impulsively expressed strong views regarding the granting of concessions in the Mosul region of Mesopotamia. Relations with the USA had become embittered by the attempt of British oil interests with government support to omit the inclusion of USA corporations in the sharing of Mosul oil concessions after the award of a British mandate. My attitude was based on the firm belief that this action was unjust considering the freedom with which British oil concerns operated in the USA, and a conviction that American cooperation, talent, and energy would not only hasten progress, but serve to check the almost certain troubles which would arise sooner or later in a rebellious population. So bitter were press recriminations that the friendly relations I had always advocated were endangered.

A well in Runcu, Romania, 1923: In rainy weather, mud slides were used for moving material.



Deep, evenly spaced perforations that *uniformly* cover the productive zone – assure you of the most effective perforating job – and that's what you get when you shoot for production with McCullough M-3 Bullet Guns.

An M-3 Gun fires all shots at one time while the gun is motionless in the casing. Thus, perforations are the exact pattern of the chambers in the gun – in any shot density desired.

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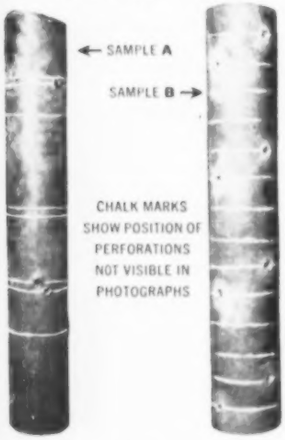
prevents bunching of shots in one small area in pay zone, giving insufficient coverage – prevents scattering of shots over a wide area, possibly missing the pay zone entirely. Sample A (actual photo of pipe recovered from well) shows the erratic shot pattern produced by a gun firing one shot at a time. As each shot is fired the upward thrust of released gases causes the gun to dance up and down.



eliminates the danger of possible pipe damage or failure. Too many perforations in one spot or in a coupling can cause pipe to part if it is in severe tension. Sample B is an actual example of six shots per foot fired by an M-3 Bullet Gun. Note the uniformity of shot pattern – no danger here of seriously weakening your casing, and you get the most productive perforating job possible.

Saboontchy field in 1898, characteristic Baku scene at that time, with earthen reservoirs in foreground.

Knowing the Navy's concern over oil supplies, I secured an interview in February 1921 with the Secretary of the Admiralty, to whom I unburdened my fears; but, although not unsympathetic and given at his request a memorandum on my views, no action was taken. A few weeks later, I was invited by Sir John Cadman of the Petroleum Executive to lunch at the Junior Carlton Club, when, obviously acquainted with my Admiralty notes, he sought to dissuade me from my views and led me to understand that the government was anti-American-inclined. I then sought, through his secretary, Mr. Davis, an interview with the Prime Minister, Mr. Lloyd George, but he likewise expressed a disinclination to meddle with affairs with which he was ignorant. In desperation, I approached the London Chamber of Commerce, which took a more serious view of the situation, and proposed that I should deliver an address on British oil supplies and raise the question of American participation in the Iraq oil fields. At a crowded meeting on October 17, 1921, I outlined the British position with regard to oil supplies, and finally stressed the importance of USA participation in developing the vast promising oil resources of Iraq. Unknown to me representatives of American interests were present, and apparently the essence of my remarks was cabled by news agencies to the USA. The widespread publication of my remarks in USA daily papers of my advocacy, and the caustic comments evoked, seemed to have led to second thoughts at Westminster for, in conversation with Cadman on November 11, 1921, I heard that my address and its reactions had caused the government considerable embarrassment. Anyway, a satisfactory arrangement was later negotiated and amicable relations re-established—which was my aim. In the interval, both the British and USA press were indulging in a spirited and acrimonious controversy concerning the validity of rival claims by sundry parties based on questionable submissions.

Although unacquainted with the nature of diplomatic representations, beyond those published, I was suddenly made aware thereof when, in June 1923, I was commissioned by London financiers to proceed with a commercial colleague to Turkey and endeavor to negotiate a concession for oil exploration in the Mosul region. The Turks were then violently opposing projected Mesopotamian partition which would deprive them of the Mosul oil-field region at the time the Allied troops were occupying Istanbul and M. Kemal and his ministers were established at Ankara. As the result of many friendly conversations with Ralph Bey, the prime minister, and other ministers of state in Ankara, I drew up at their request a draft form of agreement which could be used as a basis of negotiation for submission to Kemal. From the ministers, I heard much of Ismet Pasha's struggles at the Lausanne Conference of 1922 and of the intrigues aroused by the glamor of Mosul oil. Satisfied with the credentials we produced, sympathetic consideration was given to the granting of oil rights in Mosul which had to await an international boundary settlement. Appeasement was only secured later by granting of a 5% royalty to the Turks on all oil produced in the Mosul oil field.

A settlement with USA interests and the granting of a blanket concession over western Iraq left many aspirants for rights very dissatisfied, and matters came to a head when a selection of plots had to be made before oil in commercial quantities had been proved. Under a barrage of discontent and intrigue, the authorities decided to make a division to allot to a new international group, on rather stringent terms, all land west of the Tigris, and to old concessionaires east of the Tigris. Although considered an unjust partition, based on geographical boundaries rather than oil prospects, it offered a salutary compromise: but, faced with exacting and costly obligations and unfriendly gossip, the new group found great difficulty in raising funds. This was eventually arranged with German, French, and Italian agencies having government sposorship.

It was at this stage that, in 1932, my firm was engaged to undertake the task with a Polish engineer of reporting on the 50,000-square-mile western concession, fixing the sites for initial drilling, deciding the position of camps and the many other arrangements necessary for operating in barren country. Due to the definition of structures in arid country, a hasty reconnaissance survey of 17 folds, clearly defined by topographical uplifts, enabled me to report favorably on prospects and to fix the location of three pioneer tests in reasonably accessible positions. I was, therefore, able to reach Paris on a prearranged date, and to submit to an inquisition by the very astute government representatives of Germany, France, Italy, and those of the British group on my conclusions and recommendations. Rather rashly, I admit, I undertook, if given a free hand, to have in operation on the date designated three rigs of some sort. Just how the impossible was achieved with the help of American and British manufacturers savors of the miraculous: but it was accomplished to the exasperation of enemies who predicted failure to comply. As a matter of history, it may be mentioned that the first well drilled at Quayara was a powerful gusher of heavy asphaltic oil, the precursor of many others in the same or adjoining anticlines, but its high density and viscosity rendered its piping impossible without admixture with the lighter oils of Kirkuk. This fact and other considerations connected with politics eventually led to an amalgamation, with government sanction, of the Mosul and Iraq Petroleum groups.

A friendly association with King Feisal was unfortunately broken by his lamented death in 1936, just after I had accepted service with his government; and this event led to the first political upheaval in Iraq when Bekir Sidqui grasped power and nominated new cabinet ministers. Desirous of securing advice on petroleum matters they offered, I accepted the position of consultant to the government after inquiries had substantiated my independence at a period when important decisions had to be made regarding a projected government refinery and the granting of concessions in the Basra region following the discovery of oil in Kuwait. From a perusal of correspondence and documents, which I had been instructed to read and from interviews with ministers, I learned much which previously had appeared puzzling. Although he was imbued with socialistic inclinations, I believe the advice tendered to my minister played a part in moderating actions detrimental to existing oil interests, just as I had done in Egypt when adviser to the Egyptian government. The assassination of Bekir Sidqui in Mosul led to a somewhat insecure reversion to palace rule. These and subsequent events demonstrated how sound was my original advocacy for broad international participation in Iraqi oil affairs.

Concerning the most recent Kassem revolution, a strange and inexplicable action was the imprisonment of Pacchachi who, as minister in the last Nuri government, was mainly responsible for petroleum affairs. He was a trained scientist and no politician: he had worked for nearly a year with my firm in London studying Mosul oil in the laboratory of the Royal School of Mines. Although, as an Iraqi, he was inspired by a spirit of nationalism, he was not anti-foreign, and I think he rocognized the value

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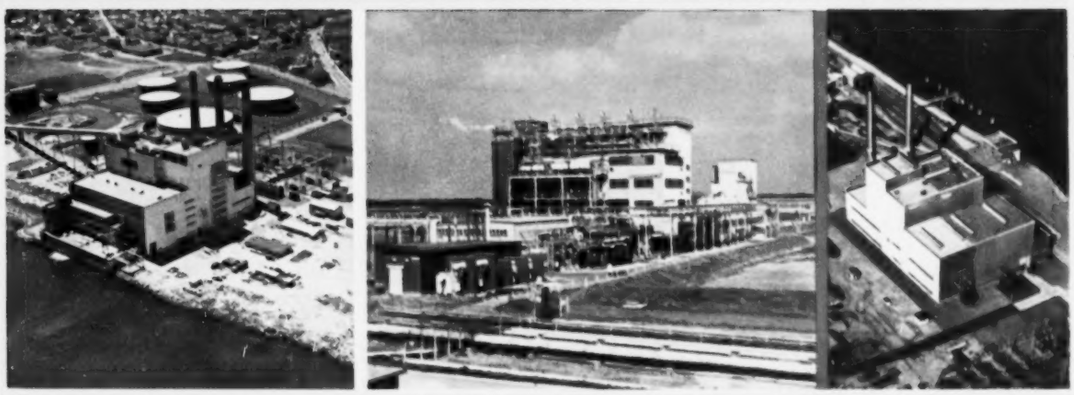

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of American and British financial and technical cooperation.

Among the many interesting and sometimes tragic episodes which one vividly recalls is that of a Bolivian venture in 1912. Intent on constructing a railway across the Andes from the Atlantic to the Pacific, that indefatigable enterprising American adventurer, Farquhar, approached the firm regarding oil prospects in the Andean foothills of Bolivia; for, without fuel for his locomotives, the project was not feasible. On agreeing that indications warranted investigation, he requested us to undertake the task not only of prospecting, but producing oil if it existed. When giving instructions, he emphasized in no uncertain language that he wanted oil and not reports; and this we promised if he was prepared to pay the cost of a fully equipped expedition with surveyor, geologists, engineers, and adequate equipment for operations in remote, wild, sparsely inhabited terrain. Two years' work in rugged Andean foothills reached from Buenos Aires led not only to the location of favorable structures disclosing oil seepages, but also to the discovery of good quality oil by drilling within a period of about two years. Unfortunately, success synchronized with a great American financial crisis, and he was unable to arrange finance for his ambitious project. In desperation, he disposed of all reports, maps, and materials to Patino, the wealthy Bolivian tin magnate, for a mere pittance. The latter sold this purchase to a Standard Oil subsidiary which, in a surprisingly short time, proved and developed a number of very useful oil fields and constructed pipelines and refineries for the local distribution and refining of crude and products. They, in turn, were subsequently deprived of their possessions by the simple method of sequestration such as became a reprehensible policy of several Latin-American States.

Looking back on over 60 years of professional association with the petroleum industry, I can honestly assert that I would not at any time have exchanged my vocation for any other, whatever the financial inducements. Nothing gave me more enjoyment and satisfaction than pioneering in wild unknown territory, and overcoming obstacles which at times appeared insurmountable. Most of my early compaigning was conducted in the hard way of foot-slogging—with the occassional help of horses, mules, donkeys, or camels—where conditions permitted their use. Nights would often be spent beside camp fires or in hastily constructed shelters where scrap meals were prepared from carried provisions. Sleep was sought on camp beds, hammocks, or upon the earth itself, if dry; and it was often necessary to carry potable water, and sometimes even that needed for culinary and ablution purposes. When penetrating exuberant tropical jungle, protection from venomous or infected insects was sought by a covering of muslin netting; and the maintenance of a smouldering fire usually kept away marauding animals. Progress through thick scrub and tangled vegetation was only accomplished by our porters hacking a passage with cutlasses, which operation disturbed and irritated all manner of hostile insects. Exploration of arid terrain and desserts was often hampered by sandstorms and cyclonic disturbances when it became scarcely possible to escape suffocation by sand or dust which penetrated nose, throat, eyes, and ears, and contaminated all food.

More dangerous still in my early exploration was the prevalence of such virulent diseases as enteric cholera, bubonic plague, and yellow fever in places where sanitation was neglected and suitable medical attention unavailable. Not until the construction of the Panama Canal by the USA was the danger removed from the Central American region of the Caribbean and the northwest Pacific coast of Peru and Ecuador. Apart from attacks of dysentery and frequent bouts of malaria, with a few minor accidents I providentially escaped any serious disabilities. Certainly, I was involved in many exciting episodes. My first experience of violence was in Baku when labor troubles and interracial conflicts led, in 1905-1906, to heavy loss of life and property, and wholesale massacres of innocent victims. As early as 1903, I witnessed attacks by Cossacks on rebellious Armenians who were defying some government decree. Life in 1910-13 was quite enlivened during the Russian Maikop boom when, with others, I shared the risk of attack from highwaymen who ambushed and robbed oil-field men suspected of carrying cash or valuables along forested tracks. During World War I, I spent much time at sea on vessels forever dodging submarines.

Distinctly unpleasant was a Mexican exploration in 1919 for a USA group where the rich Golden Lane oil-field belt was the favored haunt of desperados, insurgents, disgruntled labor and political elements fighting for supremacy, but all demanding money on threats. Within a few days of reaching Tampico in 1919, I was relieved of all my belongings when in transit on a launch along the Tamiahua lagoon. A few shots from the shore damaged the steering wheel and hull, and compelled compliance with an order to land when an armed band of ruffians demanded the heavy suitcase of the Englishman suspected of holding gold. The loss of all my belongings compelled a return to Tampico for a refit of clothes and instruments, the latter generously offered by the group of USA geologists who had collected there. A second attempt to proceed inland led to a succession of captures and interrogations by the ragged followers of the two contestants for the presidency, but on each occasion we were somewhat reluctantly released on our *bona fides* as "neutral" being established and on the removal of some of our provisions.

On reaching our objective, and camping in scrub country, several weeks were spent in dodging the bullets of opposing forces engaged in bitter conflict whilst we were engaged in geological examination of oil seepages and structures. Demands for food by one or the other side, after indecisive battles, enangered our supplies; and threats of violence did lead me to wonder whether we should return alive to the coast. However, despite many thrills, I accomplished my mission, and even made contact with the estate owner we sought, who was hiding with his family in thick forest after his house had been burned down and some members killed.

Palestine proved to be a decidedly unhealthy place while I was engaged in examining oil prospects in 1940. In consequence of the violence of the Stern gang, Jerusalem was an armed camp—with all public buildings protected by barbed wire and British troops and officials a target for hostility. A wing of the King David Hotel, then used by the British as headquarters, had been blown up with the loss of 90 lives, and like all official buildings was protected by barbed wire and sentries who demanded passes from all entrants. Frequent indiscriminate firing in the streets by the murder gangs drove peaceful citizens to shelter in shops and houses until troops appeared. In the Dead Sea region of Gebel Usdom, daily excursions into the rugged wilderness necessitated an accompaniment of four armed guards who watched our every movement. Again fate acted in my favor; for, on the completion of several weeks' work, I left my geological companion Blake, who had been government geologist, to continue certain surveys—and he was murdered with some of his guards when ambushed by a band of robbers.

On two other occasions, geological work was conducted under the protection of armed troops, without suffering ill. When with Egyptian government officials studying geology on the Sinai Red Sea littoral in 1918, the roving parties of Turkish troops had been raiding and damaging industrial establishments at Abu Zormina and Tor; and, as their movements were unknown, military guards were stationed on all nearby commanding positions whilst we worked. The second occasion arose when commissioned to examine oil prospects in a remote part of Waziristan, India, at a time when the Afridi hillmen were in revolt and under attack by British forces who protected the mountain passes. After a blunt refusal at Peshawar by the military of a pass for my projected journey, I was reluctantly given permission on condition that I take a military guard and never stray out of their sight when at work. Here again I was lucky; for, beyond Bannu, block houses were few and the country so bare and arid that I was enabled to fix at Pezu the limits of a perfect anticlinal fold by outcropping strata as clearly defined as on a map. All went well until on the return journey, in the middle of the Kohat Pass, a band of armed hillmen emerged from some trees and grouped across the road waving rifles. Acting on instructions received prior to departure, I directed my Indian driver to accelerate and, on pretense of not understanding their attitude, dashed past as they scattered. A few shots were fired, but whether as a warning or at the car I never knew, but I got safely back to Peshawar, to the evident relief of the military from whom I had inveigled a pass. END

At Keiter, Okla., in 1926, NGAA and USBM work out the "gravity balance."

NATURAL GASOLINE—

prime contributor to conservation

by Charles E. Webber*

HISTORIANS do not agree just when or where natural gasoline was first discovered. The first natural-gas wells in this country were drilled in the early part of the 19th century in New York and Pennsylvania. In the course of transporting natural gas for its early uses, it is likely that those who operated the small pipelines had problems with a liquid which condensed in the lines. Evidence to support this assumption can be found in the record of one J. W. Mettler who, in 1897 at Coraopolis, Pa., made note of his difficulties with this nuisance liquid. His 2-in. fuel line filled with what we now know to be natural gasoline. It was just a headache to Mr. Mettler,

*Sun Oil Co.; President, Natural Gasoline Assn. of America.

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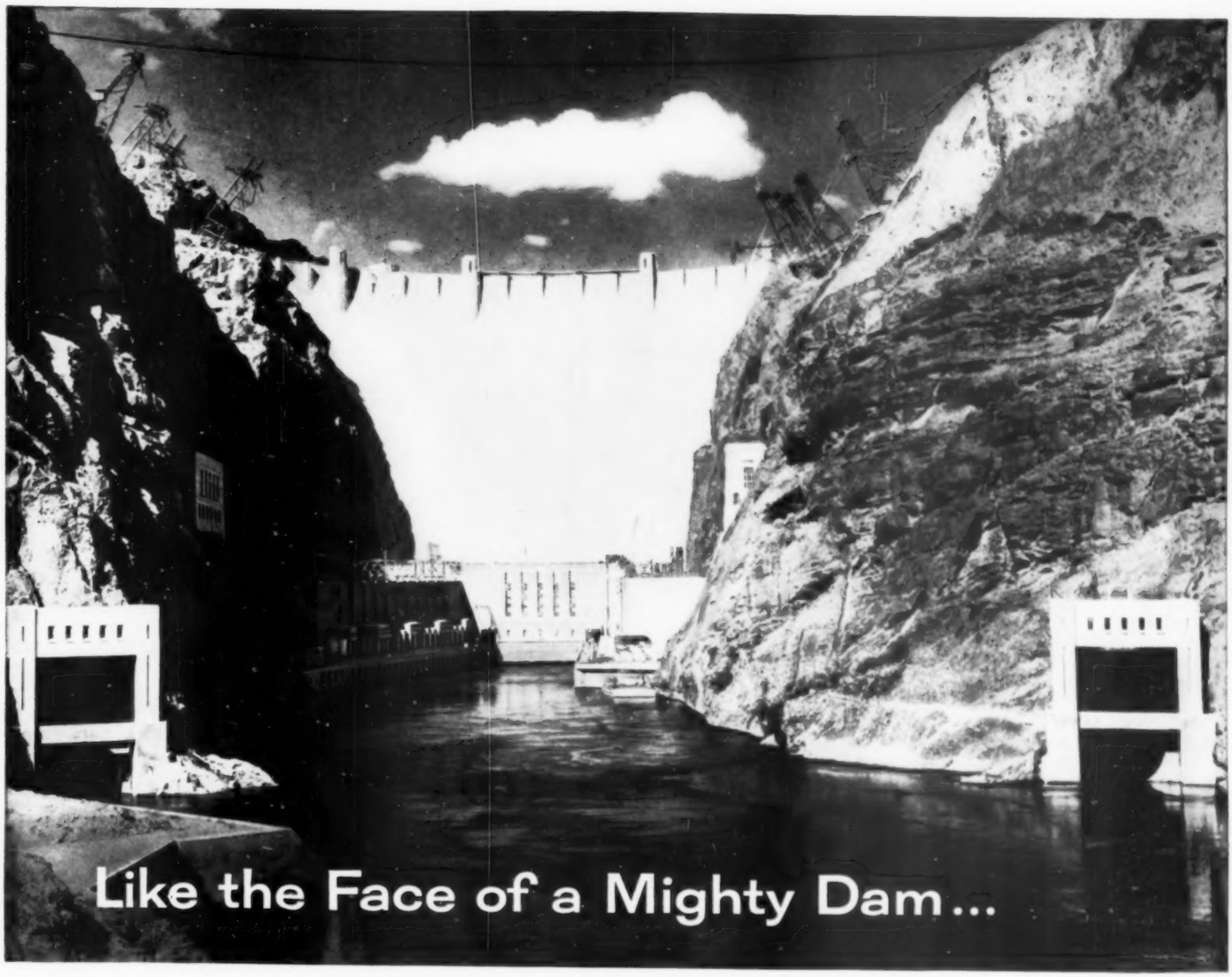

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Also forgotten... if known at all... are the facts of oil company enterprise, making it possible to drive confidently into a service station with an order to "fill 'er up." Who thinks then of far-off drilling crews, thousands of miles of pipelines, giant refineries, a fleet of supertankers, or modern research laboratories?

Yet the job could not be done without all these things. To do its share in serving the nation, Cities Service has invested a billion dollars in modern facilities... and to be ready for the even bigger job of tomorrow, it is constantly expanding. In two years, Cities Service has spent over $350 million on its progressive program.

Only in this way can America be given what it must have for progress – more jobs, more and better petroleum products.

CITIES SERVICE

An early test car for determining gasoline content of casinghead gas.

Right: First recorded vapor-pressure test of natural gasoline, near Sistersville, W. Va., in 1913, by Colonel W. B. Dunn and E. I. Harlon.

a substance without value which stopped up his line and confronted him with a problem in waste disposal.

At about the same time, Sutton Brothers and Edmonds, oil producers, were pumping natural gas produced from oil wells through lines laid across a stream near Sistersville, W. Va. Appreciable quantities of gasoline formed in the lines. This offending liquid was collected from time to time and burned. It was called "drip" gasoline. The liquid was later termed "casinghead gasoline" because it condensed from the gas coming off the casinghead of the well. Today it is generally referred to as "natural gasoline," being derived from natural gas.

The year 1903 is generally recognized as the birth of commercial operations of the natural-gasoline industry. Sutton Brothers and Edmonds, turning their adversity to advantage, set about deliberately producing natural gasoline (gravity approximately 70 API°) and marketing it in barrels. They were joined by William Franzenmayer, who built a compressor plant at Tidioute, Pa. Out of this joint venture came the Reno Oil Co. Near Sistersville, W. Va., they built what was probably the first plant specifically designed for the recovery of natural gasoline. Reno's total output in 1904 was about 4,000,000 gallons, and the gasoline sold for an average of about 10¢ per gallon. By 1908, this company had learned the basic concepts of the process of producing natural gasoline by compressing and cooling natural gas. It was obvious that greater production could be realized by higher pressures and more effective cooling. The gas-compressor manufacturers, notably Bessemer Gas Engine Co. and Ingersoll-Rand Co., became interested in building equipment for these purposes.

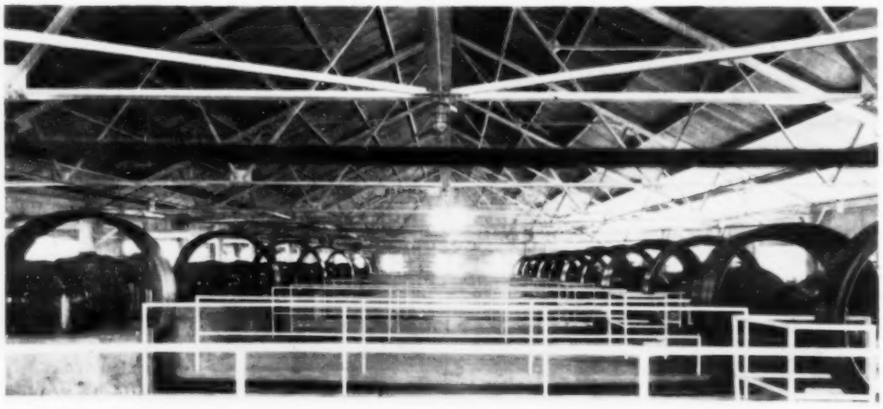
In 1912, the first so-called expansion engine for cooling gas was installed in a plant at Butler, Pa., by A. F. Clark. The expansion engine was an early refinement in natural-gasoline manufacture. Gas was expanded from a steam-engine cylinder to supply refrigeration, which cooled the main stream of warm compressed gas. In the same year, Frank Peterson, an engineer and talented mechanic who had joined the Bessemer company in 1910 to concentrate on equipment for this infant industry, built the first suitable gas-to-gas heat exchanger for cooling the main gas stream with cold expanded gas. Sometimes temperatures as low as —70 F were obtained. By this time, there were approximately 250 installations using a combination of compression and cooling to produce natural gasoline.

George Saybolt, working for Hope Natural Gasoline Co., is credited by some with the development of the oil-absorption process for gasoline recovery. He utilized ideas from the coal-tar industry of England where absorption was used to recover benzol and toluol from coal gases. Saybolt's work began in 1906, resulting in patents in 1911. The great Hastings, W. Va., absorption plant resulting from this work was constructed in 1913. It could produce about 40,000 gallons per day of natural gasoline, and was the forerunner of hundreds of similar plants. National Products Co., during the same year, built a similar but smaller plant in Oklahoma. During the next few years, the number of absorption plants increased rapidly. Saybolt's patents were attacked in 1917 by Oklahoma Natural Gas Co., and four years later the courts ruled in favor of the Oklahoma company.

A third method of recovering natural gasoline—by adsorption—was developed in 1918 by George Oberfell and George Burrell. This process was the outgrowth of experimental work on gas masks which these men had done for the government at American University in Washington, D. C. Charcoal had been used to remove poison gas from air entering World War I gas masks.

In the charcoal process for recovering natural gasoline, natural gas was passed through beds of finely ground charcoal, where liquefiable hydrocarbons were adsorbed. The charcoal beds were then flushed with steam and the vapors condensed. Oddly enough, original plants of this type were called charcoal "absorption" plants, the distinction between "absorption" and "adsorption" being somewhat obscure. Sev-

Absorption plant at Pershing, Okla., built by F. E. Rice, Phillips Petroleum, in 1920.



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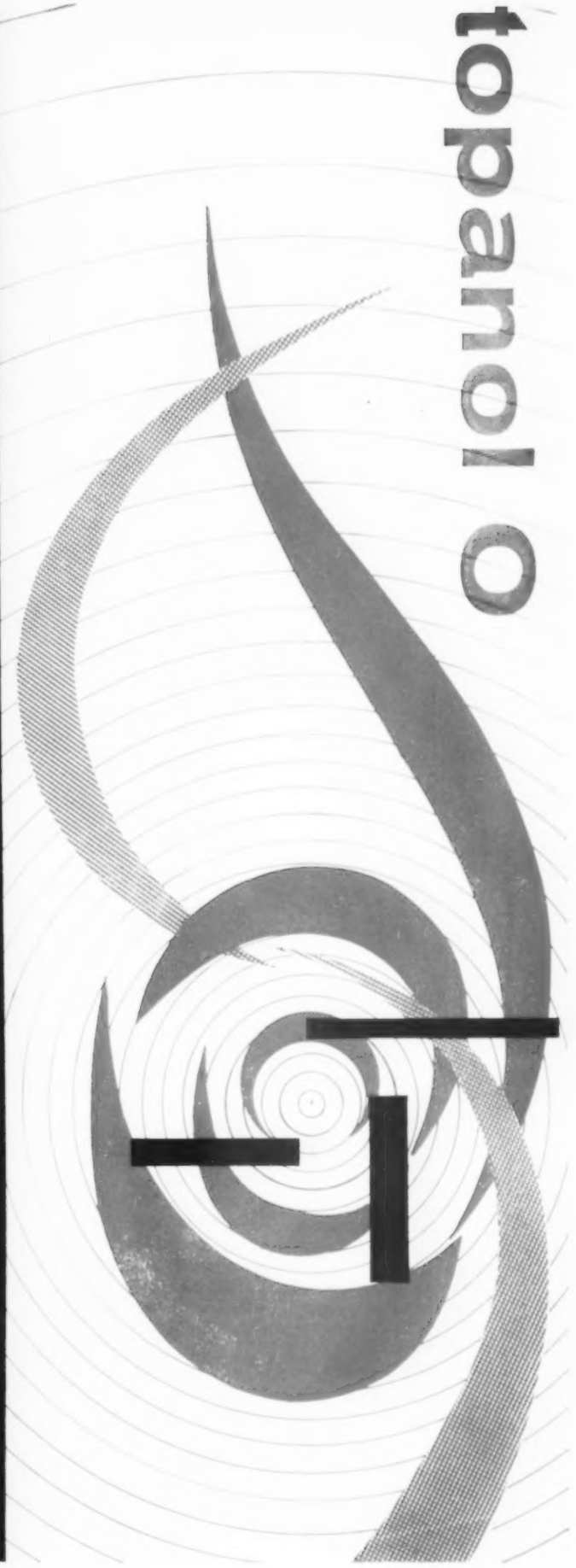

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White Plains, New York

eral plants using the charcoal-adsorption process were built in Pennsylvania.

The natural-gasoline industry probably reached maturity and general recognition in 1911 when the US Bureau of Mines published its first official report on natural-gasoline plant operations. It reported 176 plants in operation producing annually a total of approximately 7.5 million gallons, which yielded an average price of about 7.16¢ per gallon. No breakdown was given in this report as to whether these plants operated by compression and cooling, absorption, or adsorption.

The growing use of the automobile created a demand for the product from the natural-gasoline plants. Automotive engines of the period were not the severe judges of fuels they are today, and almost any blend of light hydrocarbons which would burn would give reasonable satisfaction. The natural-gasoline products were a little volatile; consequently, blends with refinery gasoline, naphtha, or even kerosine, were common. Monetary return to the producer or refiner was attractive.

Natural gasoline worked very well in automobile engines in cold weather, but in summer the public was initiated into the problems of vapor lock. Resistance to natural gasoline by both refineries and automobile owners grew. At the same time, the railroads insisted upon regulations prohibiting the shipment of these volatile materials because of the possibility of explosions and fires. One such explosion did occur at Ardmore, Okla., in 1915, killing 43 people and injuring approximately 500. It was obvious that specifications and controls were needed. In fact, work was already under way under the supervision of Colonel B. W. Dunn, of the Bureau for the Safe Transportation of Explosives.

In 1911, a group of producers in Pennsylvania, called the Gasoline Producers' Assn., met to discuss specifications to insure safety in the shipment of natural gasoline. Following this meeting, Frank Peterson began the work leading to a test for determining the vapor pressure of natural gasoline. By today's standards, the test procedures and technical approaches used in these early experiments were indeed crude. One could hardly visualize, for example, determining vapor "tension," as it was called, by building a fire under a drum of gasoline to which was attached a pressure gage, but that is how it was done. Although later supplanted by a much more refined vapor-pressure method, it was the first attempt to apply a volatility yardstick to naural gasoline and, for many years, it was practically the only such yardstick.

In April 1921, The Assn. of Casinghead Gasoline Manufacturers was organized in Tulsa, Okla. Its efforts were directed toward realistic specifications and test procedures on natural gasoline and liquefied petroleum gas. At that time, there had evolved more than 100 different grades of this light hydrocarbon product. Simplification and standardization had become imperative. The wide differences in purchase contracts offered by gasoline-plant operators to gas producers required a staff of lawyers for both parties.

Soon after its organization, The Assn. of Casinghead Gasoline Manufacturers changed its name, adopting the term "natural gasoline" and dropping the stigmatized word "casinghead." It set about solving the problems created by lack of standards in specifications, test procedures, and business practices. Within a year, it proposed a simplified and much improved set of specifications for natural gasoline, listing six grades as determined by gravity, boiling point, color, vapor pressure, and recovery during a distillation test. Adoption of these specifications represented a great stride in reducing confusion.

On the West Coast, where the natural-gas industry had also been growing rapidly, the California Natural Gasoline Assn. was formed in 1925 by a group of the leading technical men in that state. It played the leading role in establishing technical standards which guided the operations of natural-gasoline plants in California.

One of the most significant test methods developed during this period, and important to the entire petroleum industry, was the Reid vapor-pressure test. It was submitted by Walter Reid, of Lone Star Gas Co., in a prize contest sponsored by the Natural Gasoline Assn. of America. This test was immediately adopted to replace the old "vapor-tention" method. It made possible a new set of specifications and test methods covering various grades of natural gasoline.

The Natural Gasoline Assn. of America worked with the Interstate Commerce Commission and the Bureau of Mines to eliminate transportation hazards and to establish sound regulations. It met with railroad men to discuss tank-car construction. It conducted a study of gas-purchase contracts, and issued a general form as a guide which contracting parties might use if they so desired. All of this has a stabilizing influence upon the industry. It was needed particularly at this time because its first big setback had just occurred. This was the complete withdrawal of a major natural-gasoline purchaser from the market, causing a disruption in the price structure.

All during this period, there was a constant clamor for better and mose salable products and for removal of the wild components of natural gasoline. At the 1923 meeting of the Natural Gasoline Assn. of America, James Rafferty of Carbide & Carbon Chemicals Co. announced a fractionation process patented by his company. Its terrific import was not immediately realized, but it held the solution to practically all problems of volatility. The process was commonly referred to as "stabilization." Even today, gasoline-plant fractionators are commonly called stabilizers. Carbide had also bought the American patent rights to a similar process developed for Shell Oil Co. These patents were challenged by Phillips Petroleum Co. and others and, after lengthy litigation, they were invalidated. During this litigation, the industry received a real education, and the doors were opened to fractionation of commercially pure ethane, propane, butanes, etc.

This also was the beginning of an era of improved plant design in many other respects. The old and smaller plants were replaced by larger and more efficient ones. Compressor installations which had been largely limited to single-stage operation was expanded to multiple-stage operation. Processing pressures began to exceed the usual 300 psi vicinity. The widespread use of stabilizers permitted increased production of liquefied petroleum gases, although the market for LPGas was in its infancy. Old direct-fired stills were replaced by steam stills. Automatic controls were put into general use. By 1931, there were 364 operators in the natural-gasoline business, and 1,087 plants were producing 7,000,000 gallons per day. The bulk of this production was sold to refineries. As the industry matured, the demand for improved equipment was stimulated, and many manufacturers devoted their entire output to natural-gasoline plant equipment. A group of these firms formed the Natural Gasoline Supply Men's Assn. in 1927, with J. H. Satterwhite, of Westcott & Greis, as president. Since its inception, this association has worked closely with the industry, and has a membership exceeding 200 supply and engineering companies.

A few of the outstanding developments of this period should be mentioned. In 1930, Alois Kremser of the Standard Oil Co. of California introduced his mathematical procedure for designing gas absorbers. George Granger Brown of the University of Michigan was retained by the Natural Gasoline Assn. of America to conduct engine experiments with various blends of natural and refined gasolines to demonstrate the valuable characteristics of the natural product. He and D. E. Buchanan traveled to meetings of refiners with a "tent show" in which they demonstrated the use of natural gasoline as a motor fuel.

Studies of the use of natural gasoline in motor fuels continued through a number of years; and, in the 1930's, culminated in the well-known full-scale road tests at Pawhuska, Okla., in 1938. The natural-gasoline producers maintained a continuous campaign to promote the use of more natural gasoline in motor fuels.

But in spite of all these technological advances, the 1930's brought the most depressing influences the industry had yet experienced. Coupled with the worldwide depression, beginning in about 1930, there were discovered the huge oil and gas fields in the Texas Panhandle and the tremendous East Texas field. Gas production from these fields brought many new processing plants into being, and their output further aggravated the existing problem of oversupply. At the same time, refineries were entering the octane race, and were cracking crude oils and thus producing many of the volatile

Katy gas cycling plant, operated by Humble for 31 companies: Now little more than 16 years old, plant has recovered over 100 million barrels of liquid hydrocarbons from Katy gas field.

fractions they needed for blending in motor gasoline. As a result, the price of natural gasoline sank to an all-time low of about 1¢ per gallon in 1932.

In the middle 1930's, a different type of gas-processing operation, never before seen, was introduced. Dr. William N. Lacey, of The California Institute of Technology, explained the physical maxim whereby a light hydrocarbon material, called "condensate," dropped out in separators when extremely high-pressure gas was reduced in temperature and pressure. This phenomenon was immediately termed "retrograde condensation." Dozens of gas-condensate reservoirs had been discovered along the Gulf Coast of Texas and Louisiana and in California. There was no market for the natural gas and, in order to realize income, the owners of these reservoirs installed gas-cycling plants to recover liquid products and returned the residue to the reservoir to maintain its pressure. Today, these operations are completely intermingled with the recovery of natural gasoline, and many have forgotten that at one time the operators of these gas-cycling plants had their own trade association. It was merged into the Natural Gasoline Assn. of America in 1941.

In 1937, to stimulate new development and to honor those who had served the natural-gasoline industry outstandingly, E. I. Hanlon, a prominent member of the industry and currently board chairman of the National Bank of Tulsa, initiated the Hanlon Award. It is given each year to one in the industry who has done outstanding work, or who has initiated some new development or made some outstanding contribution on behalf of the industry. Many of the men mentioned herein, in addition to many others, have received the Hanlon Award.

World War II brought about an accelerated increase in the production of natural gasoline, liquefied petroleum gas, and related products. Under a broad program outlined by the Petroleum Administration for War and necessitated by the demand for light hydrocarbons for alkylation in aviation-gasoline components, synthetic rubber, and fuels, a new period of growth developed. Production practically doubled during the war. Vast new plants and additions were constructed. Unit operations in the oil and gas fields brought about unit operations of processing plants. Many producers envisioned problems of oversupply at the cessation of hostilities. They never materialized. Construction continued. The use of LPGas continued to grow. Underground storage leveled out much of the feast-and-famine aspect of this business, and it has thrived.

At the present time, production from the almost 600 natural-gasoline plants in the United States exceeds 850,000 b/d. Even though a worldwide oversupply of crude oil has resulted in the curtailment of domestic oil production and its accompanying natural-gas production, the increased demand for natural gas as a fuel has caused production from gas wells to soar. This has necessitated a continued expansion in gas-processing plants. Plants on the drawing boards and under construction today will materially add to the current level of production within the next few years. One of these proposes to process approximately 700 million cubic feet daily. Liquid output from this one plant will rival that of a major USA oil field.

The natural-gasoline industry is no longer the unwanted child of the petroleum industry, as it once was considered. Truly, it can be said that this industry has swung in a wide arc. It began as a nuisance; was repudiated in the '30's as a motor fuel; was viewed as a necessary evil by producers and refiners; obtained a measure of respectability and acceptance in the 1940's; and has since reached significant stature. It might well be renamed the "natural-gas processing industry."

Underground storage at both the point of production and in consuming areas has done a lot to stabilize LPGas markets. This is the largest part of natural-gasoline plant output. But the natural-gasoline portion of the overall production still faces that old challenge of meeting octane requirements as a motor fuel. The value of natural gasoline will depend upon whether the operator of a plant can upgrade his product so that it can be used directly in motor fuel. If he cannot, he must be satisfied with its value as a feed stock to refinery units for whatever purpose the refiner can use it, and to the chemical industry where promising opportunities as a raw material exist. END

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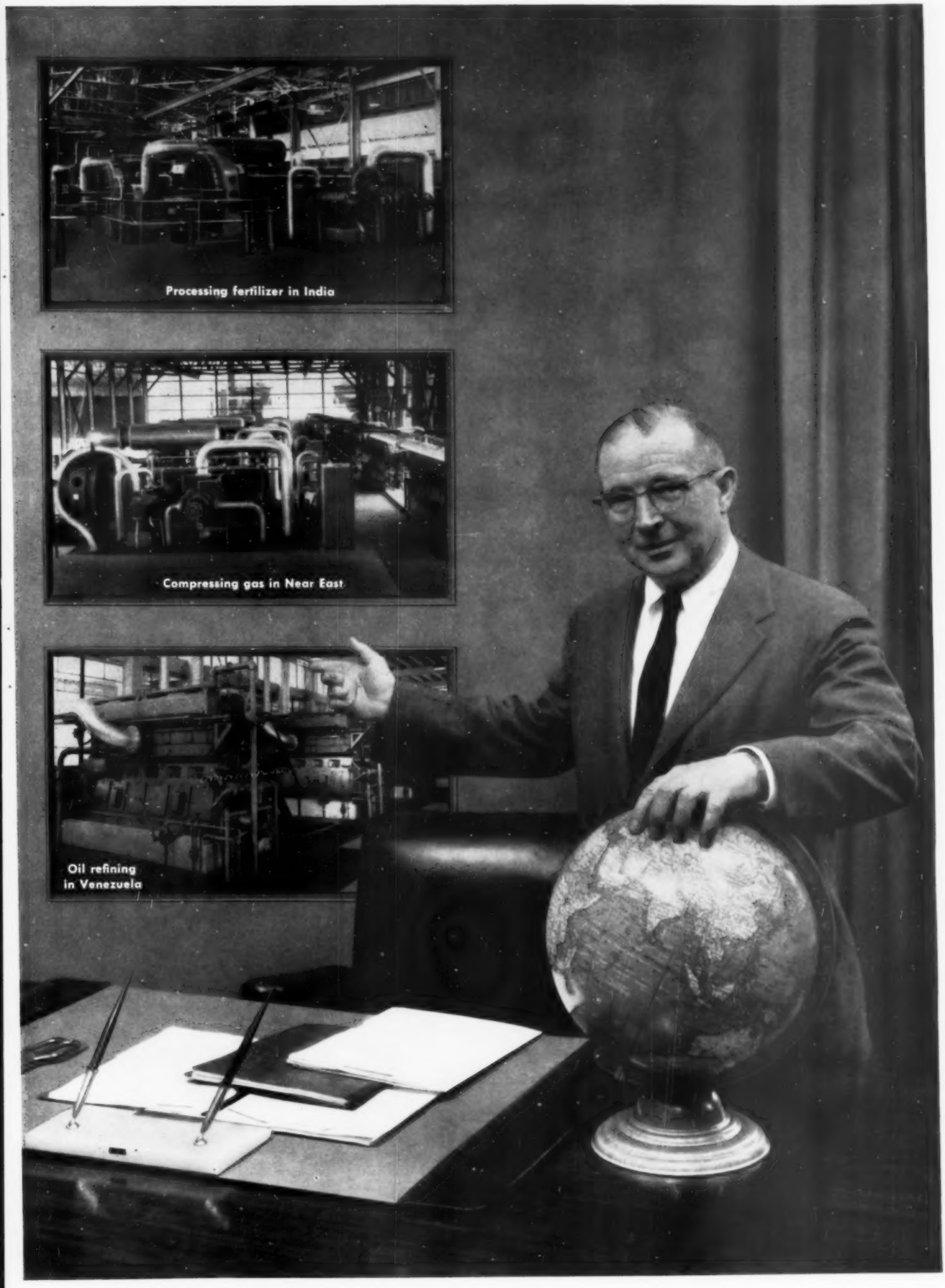
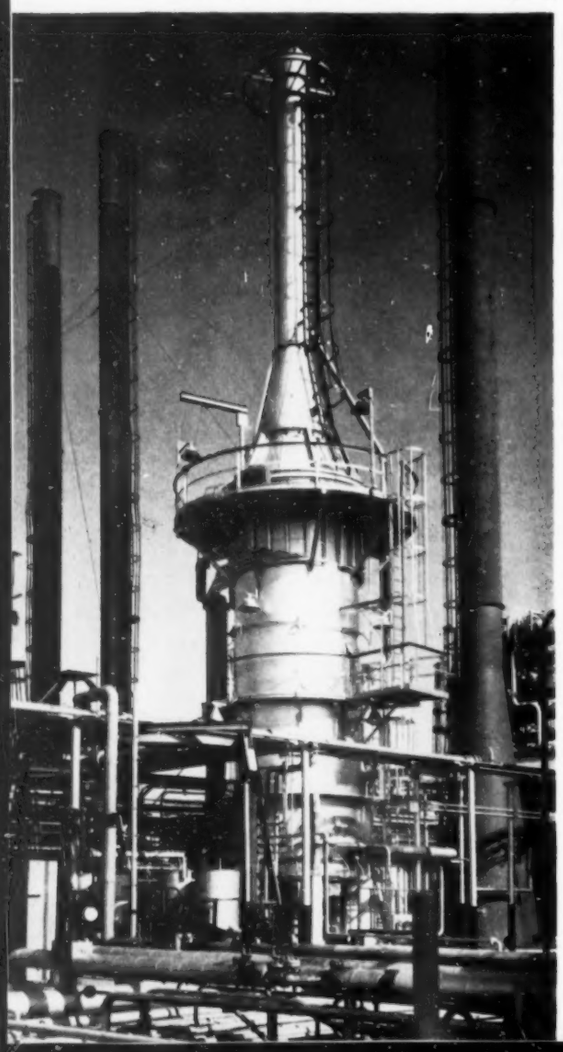

Processing fertilizer in India
Compressing gas in Near East
Oil refining in Venezuela

Shell's Contribution To The UK Petroleum Chemical Industry

THE first petroleum chemical plant to be built outside the USA was in the UK, and was started up at Stanlow in Cheshire in 1942. This plant was Shell's first unit for the production of "Teepol" liquid synthetic detergent. The Royal Dutch/Shell group of companies was, however, not only the first producer of petroleum chemicals in Europe, but was also a leader in the petroleum chemical industry of the USA, which by then was well established.

Immediate postwar developments in the UK were rather slow, and the major developments have taken place within the past seven years. Two factors were mainly responsible for the slower initial growth. The UK, unlike the USA, had very few refinery byproduct gases available until the large home refineries using Middle East crudes came onstream; and, as a consequence, the petroleum chemical industry had to make use of olefins derived from oil specially cracked for this purpose. The second factor was that the markets for the products which could be made from petroleum at that time were still in a stage of development which limited the number of economic sized units which could operate.

Dimethylketone converter for Shell Refining & Marketing Co. Ltd., at Stanlow, Cheshire, England.



As the production of petroleum chemicals grew with the expansion of the markets, the demand for olefins might have been met to some extent by making full use of refinery gases, but only limited opportunities for this became available. A large part of the industry has continued to make use of liquid feed stocks for special cracking, and this is a well-established feature of the UK industry. In this respect, the UK developments contrast sharply with those of the industry in the USA, where today olefins are obtained partly from refineries and partly from the cracking of natural gas. There are no sources of the latter available for use in the UK.

As would be expected, the greater part of the UK petroleum chemical output is in the form of organic chemicals, and in 1957 these latter made up roughly 80% of the total output, by weight. The growth of the industry in the UK has been spectacular; between 1950 and the end of 1957 the output of all types of petroleum chemicals rose from 50,000 tons per annum to nearly 600,000 tons per annum. This represents a growth rate of 40% per annum, which compares with the average growth rate over the same period for all chemicals in the UK of just over 6% per annum, and just under 3% per annum for industrial production as a whole.

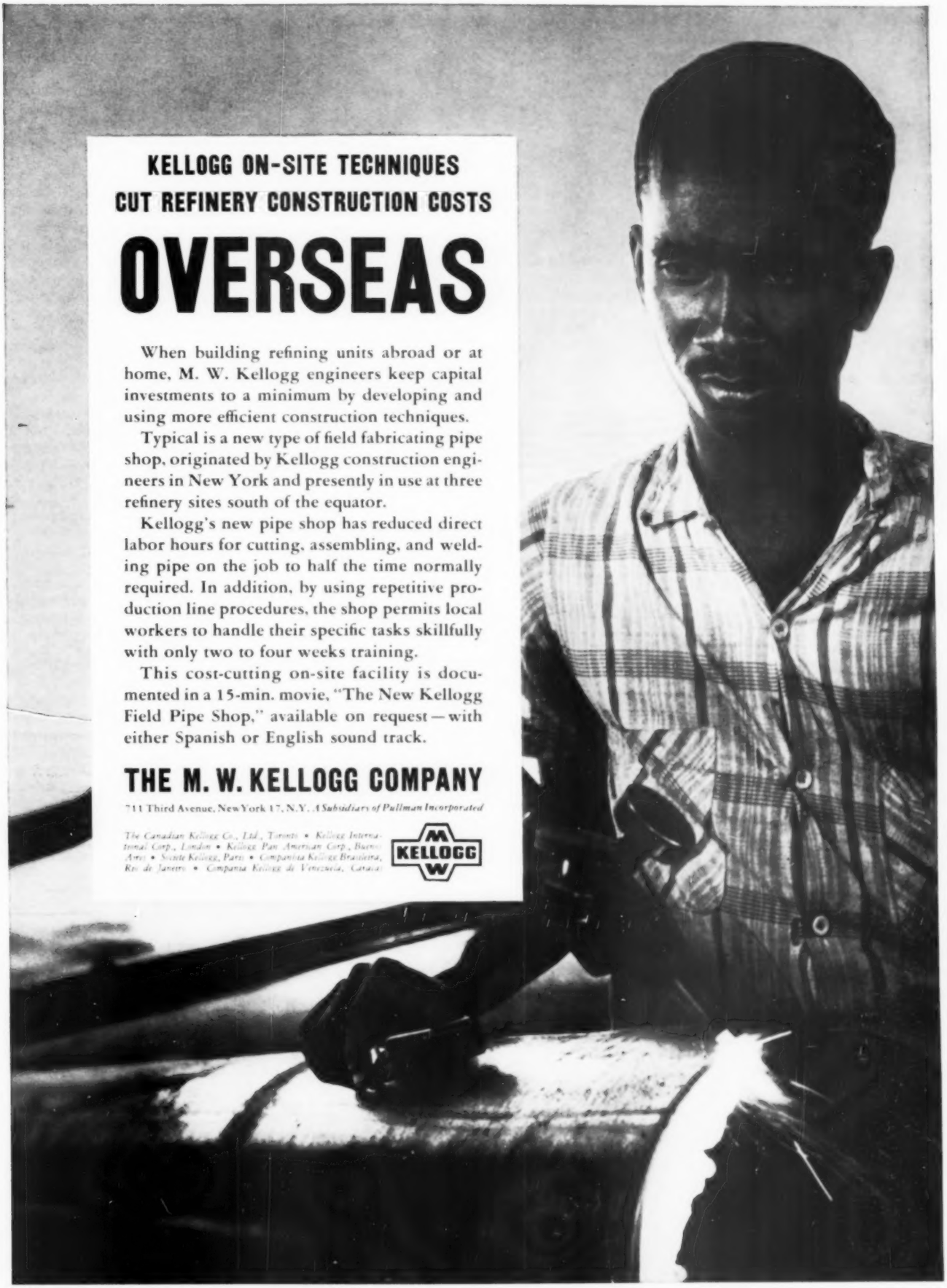
Since the time when petroleum chemicals were first made in the UK, most of the leading industrialized countries of the world have followed the example of the UK and entered the petroleum chemical field. The UK, nevertheless, has retained its lead, and at the beginning of 1958 its output represented over 25% of the total output of the free world excluding the USA.

Petroleum chemicals have made very important contributions to the development of the chemical industry, notably in the fields of detergents, synthetic solvents, plastics, resins, synthetic rubber, fertilizers, and other agricultural chemicals, and chemicals for the automotive and aircraft industries. Apart from these well-defined sectors of the present-day chemical industry, petroleum is the basis for the manufacture of many important chemical products and intermediates employed in other branches of industry and commerce.

In the detergents field, enormous strides have been made since Shell introduced the petroleum-based synthetic detergent "Teepol." It is estimated that over 40% of all washing and cleaning materials currently used in the United Kingdom are petroleum-derived synthetic detergents. The alkyl aryl sulfonates constitute the bulk of UK output of these products. The alkyl aryl sulfonates are themselves obtained from petroleum-based detergent alkylate. Shell is a leading producer of detergent alkylate in the UK at the 30,000-ton-per-year capacity plant at Shell Haven which came onstream in 1956. The output of this plant supplies both the home market and export market, thereby contributing an important source of foreign currency for the UK. The production of the liquid detergent "Teepol" by Shell at Stanlow has already been mentioned. "Teepol" is obtained by the sulfation of olefins obtained from a petroleum raw material. Its exceptional efficiency as a detergent makes it of great importance as a cleansing material in both the home and in industry. Shell also produces a third type of synthetic detergent from petroleum, the nonionic class of product sold under the name "Nonidet" and based on ethylene oxide. These detergents are made at Shell's Carrington works, near Manchester.

The production of chemical solvents in the UK is now based entirely on petroleum raw materials with the exception of a minor quantity of ethyl alcohol. These chemicals are derived from propylene and butylenes. The large chemical solvents plant operated by Shell at Stanlow was brought onstream in 1949. It makes a range of propylene derivatives, including isopropyl alcohol, acetone, diacetone alcohol, methyl isobutyl ketone, and methyl isobutyl carbinol. From butylene, the plant produces secondary butanol and methyl ethyl ketone. A range of important high-boiling solvents based on ethylene and propyl glycols, the "Oxitol" and "Proxitol" solvents, are made at the Carrington plant. It is also interesting to note that the very large units for the production of ethyl alcohol from ethylene in the UK, operated by British Hydrocarbon Chemicals Ltd., employ the Shell direct hydration ethanol process.

Probably the most striking developments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in chemicals in recent years have been in the sector of plastics and resins. The tremendous growth of output of these materials, especially the thermoplastic types, which are already more important than the older established thermosetting plastics, has taken place very largely because of the availability of bulk supplies of intermediates produced by the petroleum chemical industry. Shell has participated very fully in these developments. In the UK, Shell now operates a polystyrene plant at Carrington which produces a wide variety of products. A recent addition to the existing line of products has been the introduction of expanded polystyrene in the form of extremely light-weight board, suitable particularly for heat insulation purposes, as for example in refrigeration. At the moment, styrene monomer for conversion to polystyrene is not being produced by Shell in the UK, but a plant is under construction to meet Shell's own requirements as well as to allow sales to others. This plant will make use of ethylene obtained from petroleum sources.

Probably the best-known petroleum-based plastics is polyethylene, and this is produced on a large scale in the UK by means of a high-pressure process. Other methods of manufacture, producing polyethylenes by low-pressure techniques, have now become available. Shell has built and brought into operation at Carrington the first plant in the UK to make polyethylene on a semicommercial scale by one of these methods. The process was developed by Shell on the basis of the patents of Professor K. Ziegler for which Shell has the exclusive rights in the UK.

Shell has recently been first to make available to the UK plastics industry trial quantities of polypropylene, a polyolefin plastic material with highly interesting properties for a variety of end uses. This product, for which a very bright future seems assured, will be produced commercially by Shell in the UK in an integrated plant at Carrington, capable of making some 30,000 tons per annum of polyethylenes and polypropylenes.

In the field of synthetic resins, Shell has established an important position with the range of "Epikote" resins. These epoxy resins, which are made from petroleum chemical intermediates, have become of great importance in the surface-coating industry due to their exceptional properties of toughness, adhesion, and resistance to chemical attack. "Epikote" resins, which are made at Stanlow, are produced also in liquid grades which can be used in other applications, as for example in "potting" electrical circuits, laminating castings, and the production of foundry patterns.

The manufacture of synthetic ammonia, using hydrogen derived from petroleum sources, is fast becoming the most important route by which ammonia is made. Ammonia is the basis of synthetic nitrogenous fertilizers, and is itself the precursor of nitric acid and urea. The growth in consumption of nitrogenous fertilizers in the world has been extremely rapid in recent years, and the need to increase crop yields will continue to expand the demand. Shell already holds an important position in the world as a producer of ammonia, and this output will shortly be increased by the startup of a large ammonia plant at Shell Haven, in Essex. This plant will have capacity for some 75,000 tons per year of ammonia, part of which will be converted to nitric acid. A substantial proportion of both products will be sold to Fisons Ltd., an important UK fertilizer manufacturer, for the production of compound fertilizers; the remainder will be used by Shell to make "Nitra-Shell," a solid fertilizer based on chalk and ammonium nitrate.

Petroleum contributes to another important branch of the agricultural chemical field, the manufacture of insecticidal and herbicidal compounds. Shell markets a wide range of such materials in the UK, many with a petroleum base. Although not produced in the UK, mention must be made of the important range of insecticides aldrin, dieldrin and endrin, as well as the soil fumigants "Nemagon" and DD.

Chemicals from oil make an important contribution to the manufacture of the highly-specialized materials employed by the oil industry to enhance the qualities of oil products. Typical examples include the manufacture of tetraethyl lead from petroleum ethylene and ethane, which in the UK is supplied by Shell to Associated Ethyl Co. Ltd., the sole producers, and the manufacture of additives for lubricating oils, and of anti-freeze compounds and aircraft-engine coolants, both of the latter being based on ethylene glycol.

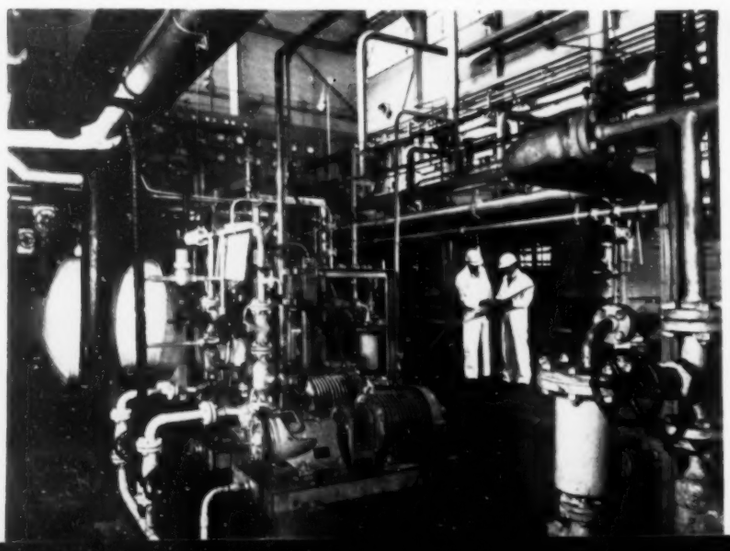
Among the important chemical intermediates made from petroleum may be mentioned ethyl and propylene oxides and their derivative chemicals, the glycols, amines, and glycol ethers. The range of applications into which these products enter is extremely wide, and some have already been mentioned in connection with high-boiling solvents and anti-freeze. Shell is completing an expansion of existing facilities for this range of chemicals at the Carrington site, and the new unit will have capacity, as olefin oxides, for some 25,000 tons per annum. Almost all of the oxides will be converted into derivatives, the balance between them adjusted according to market requirements.

The maintenance of Shell's prominent position in the UK petroleum chemical industry, as well as in the international petroleum chemical field, is assured by the support of a strong and well equipped research organization, centered in Europe and the USA. In the specialized field of agricultural chemicals, Shell is among the leaders in the UK, having a large research station and experimental farm at Woodstock in Kent. A further laboratory in the UK, engaged primarily on research in the plastics and high polymers field, is located at Carrington. Assistance to customers in the industrial chemical and plastics fields is provided by the modern customer-service laboratories of Shell Chemical Co. Ltd. at Egham, in Surrey, opened in 1956.

The continued growth of the petroleum chemical industry of the UK at a high rate is certainly to be expected, particularly in the organic chemical sector where increasing demand for consumer goods, made from materials such as fibres and resins, is opening up new outlets for such chemicals. The scale of investment in petroleum organic chemicals in the UK had already reached £76 million by the end of 1957, and by the end of 1960 a further investment of £66 million is planned, raising the total to £142 million. These figures amply illustrate the confidence felt in the industry in its own future.

END

Shell's Stanlow refinery, with crude capacity of five million tons per year, manufactures a wide range of products, including chemicals from petroleum.



Styrene products plant at Carrington, Manchester, for polystyrene production, of Petrochemicals Ltd., subsidiary of Shell Petroleum Co. Ltd.

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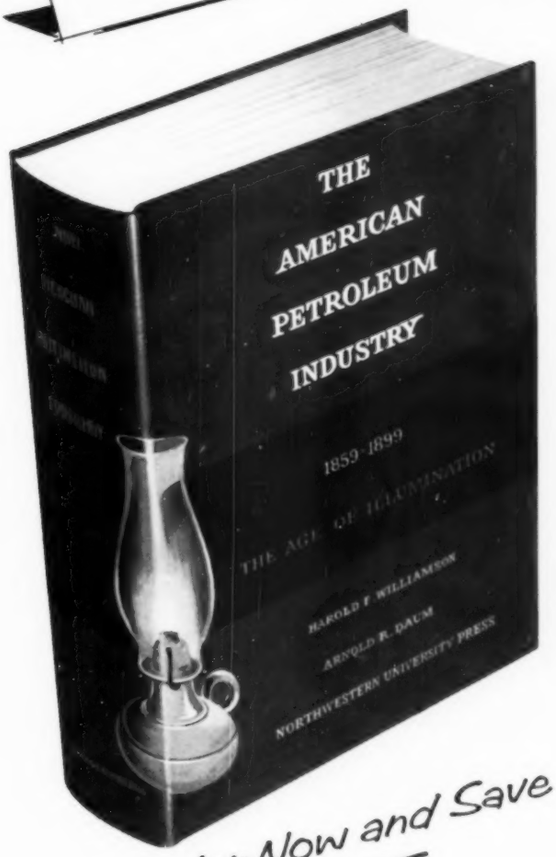

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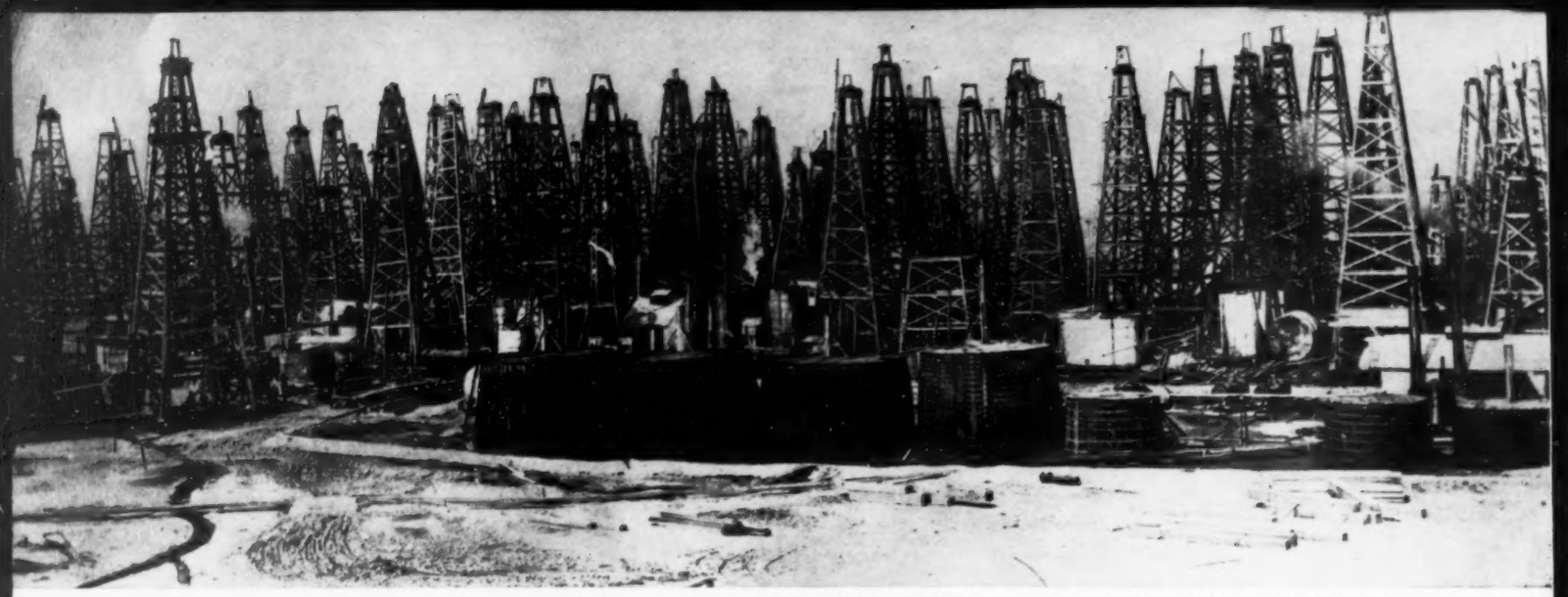


Tract owned by former Texas governor James S. Hogg and his partner James S. Swayne at Spindletop around 1901, one of the most productive in the field (photo, courtesy Fred A. Schell).

100 YEARS OF OIL PRODUCTION

by Dr. Lester C. Uren*

SINCE the day in August 1859 when the Drake well began the modern cycle of oil production, the world has produced approximately 110 billion barrels of petroleum. Few people have any adequate concept of the magnitude of such a figure or the physical volume which such a quantity of petroleum would assume. Perhaps we could visualize it by picturing it stored in 85,000-bbl tanks, 144 ft in diameter and 29½ ft high, placed in a straight line with their circumferences touching. A line of tanks of this size, arranged in the manner suggested, of sufficient capacity to contain all of the crude petroleum produced during the period under review, would extend 1.4 times around the earth at the equator. Expressed another way, the oil volume would be 4.2 cubic miles.

This great volume of fluid, accompanied perhaps by an equal volume of water, had to be drained into the recovery wells through the minute pore spaces of the surrounding reservoir rock; lifted to the surface from wells averaging several thousand feet in depth; separated from the accompanying gas, water, and sediment; gauged, sampled, and tested for quality; and stored in tanks or reservoirs before shipment through pipelines and by ships and railroads to distant refineries. When one considers the physical problems involved in such a task, the true magnitude of the world's petroleum-producing industry begins to become apparent.

This is a dynamic industry which has been growing in stature almost every year since it began. If we were to plot the production of petroleum, year by year, on semilogarithmic coordinates, we would find that production has been increasing at an almost constant rate. Since World War II, except for the year 1958, production has increased at an average rate of 6.3% per year.

World production during the first four decades of the petroleum industry was small in comparison with the great strides which have been made since 1900. The accompanying table shows how the production, by 10-year periods, has been increasing since 1859. More than half of the production for the entire 100 years has come during the past 15 years. The rapidly increasing demand for petroleum promises to continue as long as new supplies can be found and produced at a price competitive with the cost of substitute products. Substitute oil products may be derived from oil shale or coal at prices not greatly in excess of those presently produced from petroleum.

World petroleum production statistics during recent years must remain somewhat uncertain because exact figures for the USSR and its satellite countries are not published, but the table contains estimates for these countries which are believed to be sufficiently accurate to serve the purposes for which they are here used.

Today, the petroleum-producing industry is worldwide in scope, commercially productive fields being found in every continent and in 50 countries. From the beginning of the industry in 1859, the United States has been the principal producer of petroleum and its products, except for a brief period (1898-1901) when Russia was the world's leading producer. Of the world's total production during the period 1859-1958, the United States has produced more than half of the world's supply. The USA has also been the largest consumer of petroleum products through all the years since the beginning of the industry in 1859. During recent years, the USA has been consuming more than half of the world's production of petroleum products, and currently consumes more than she produces.

The United States has also consistently maintained substantial reserves of crude petroleum available for future use, but at present possesses only about 16% of the world's total known reserves. During recent years, discoveries of large new reserves in countries of the Middle East (principally Kuwait, Saudi Arabia, Iran, and Iraq) have given this region about two-thirds of the world's known reserves. These countries are comparatively small consumers of petroleum products; consequently, they have substantial surpluses available for export. Individual well productions are large, and unit production costs low; hence Middle East oil exerts a powerful influence on crude-petroleum world markets.

Petroleum Production Methods: Oil-Lifting Methods—Most wells completed in USA oil fields require some form of artificial lift, i.e., pneumatic or mechanical lifting devices, to bring their oil to the surface. Of about half a million wells currently producing, only about 68,000 are capable of flowing their production unaided. Each year, about 25,000 wells are equipped for artificial lift, requiring an investment of many millions of dollars in new well equipment. Artificial-lift equipment maintenance cost for existing wells is estimated at about $81 million per year.

The early producers of petroleum employed primitive and inefficient methods of production. The first oil produced by the Drake well was bailed from the well, a few gallons at a time. Some of the early wells

* Emeritus Professor of Petroleum Engineering, University of California, Berkeley, Calif.

in the Appalachian fields flowed their production unaided for a short time, but a pumping device of some kind had to be devised for sustained production during the later lives of the wells. In those early days of the industry, producers had but a vague understanding of the forces causing flow of oil and gas through and from the reservoir rock; they paid little attention to methods of well completion and maintenance; their well logs recorded little more than the overall depth of the well and the depth to the top of the reservoir rock. Individual-well production records were seldom maintained.

Wells were shallow—often but a few hundred feet deep—and the early oil-well pumps consisted of a leather-packed plunger in a short working barrel, actuated by a column of reciprocating sucker rods, suspended at the surface from one end of a wooden walking beam. Two ball-shaped valves on disc-shaped seats, one in the lower end of the working barrel and one in the plunger, opened and closed with each stroke of the rods, lifting oil toward the surface through a column of tubing on which the pump was suspended below the surface of fluid in the well. Working barrels were small and plunger strokes short, and pump capacities were low.

Steam engines were used for operating the pumps, it being customary after completion of a well to use the engine and rig which had been used for drilling for subsequent pumping service. "Standard" cable-tool rigs were used for drilling, and the belting and bandwheel crank and pitman mechanism of the drilling were left in their same position for actuating the walking beam and reciprocating the rods in pumping service. The early "standard" rigs were constructed largely of hard-wood components and, with continued use in pumping service, soon became loose in the joints, warped, and mechanically inefficient. Even the sucker rods in early pumping service were wooden poles joined end to end by riveted iron straps.

While primitive and inefficient, the standard rig "front" was continued in pumping service for 60 years or more. Indeed, some are still to be found in operation in the older fields. Improvements were made, however, in later years. For use in the deeper wells, the bandwheel, pitman, walking beam, and the principal supporting posts and beams were constructed of steel, so that the several parts of the rig could be maintained in better alignment and mechanical condition than in the older wooden rigs. And, with the development of suitable types of gas engines and electric motors, they have almost entirely supplanted the more expensive steam engine in pumping service.

The standard rig "front," at best, presents many opportunities for loss in mechanical efficiency as a result of belt slippage and frictional losses at many points of rolling and sliding contact. Engineers who began to take over the design and operation of deep-well pumping mechanisms in the early '20's sought a better type of equipment for applying power to rod pumping in the oil fields. The result has been the modern pumping "unit" which, through the past three decades, has progressed through several stages of development. Today, most of the older standard rig "fronts" have been replaced with modern pumping units, and nearly all new pumping wells are so equipped. Especially is this true of wells drilled with rotary equipment.

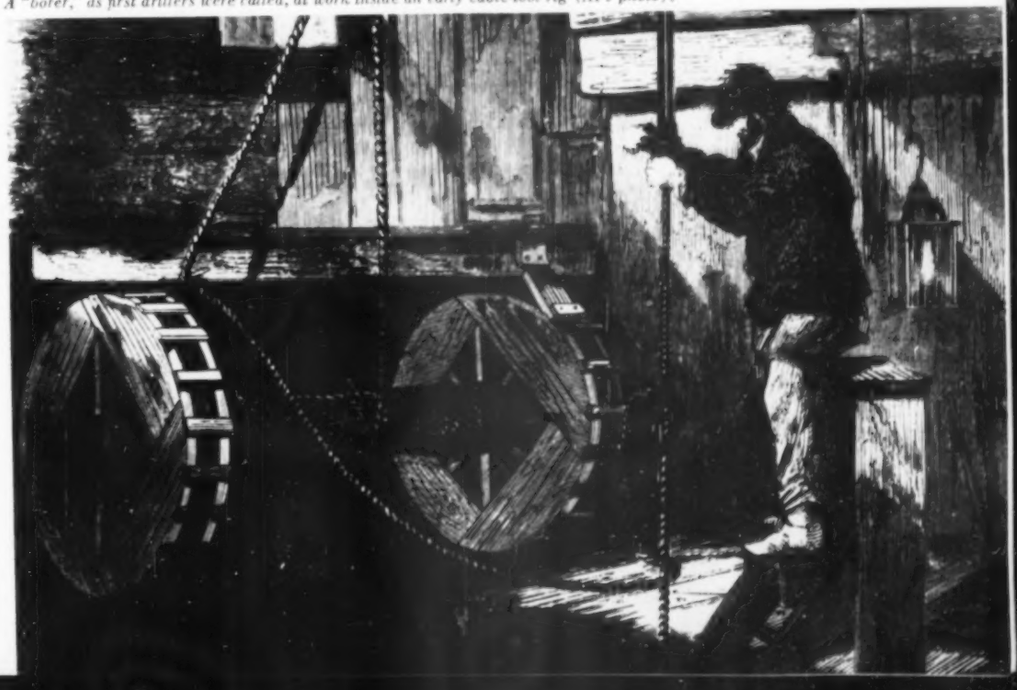
A variety of different types of pumping units are available. Most of them employ a crank pitman-walking beam mechanism to change the rotating motion of the engine or motor-drive pulley to the reciprocating motion of the sucker rods. The walking beam is supported on a samson post or steel A-frame or tripod. Speed reduction from that of the engine or motor-drive pulley to that of the sucker rods is accomplished by a V-belt or chain-and-sprocket drive or by gearing of either worm, single-helical, or herringbone type. Herringbone gearing is mechanically the most efficient. Some pumping units accomplish the necessary speed reduction in one stage; others use two, or even three, stages. Either a gas engine or an electric motor may be used as a source of power. Some method of balancing the load of the sucker rods is usually provided. This may take the form of an extra load attached to the crank, pitman, or the pitman end of the walking beam. Air-balanced units provide a piston operating in an air-compressor cylinder, attached in a vertical position to the pitman end of the walking beam. On the well end of the walking beam, a "mulehead" and beam hanger provide a straight-upward pull on the polished rod.

The modern pumping unit is constructed entirely of steel components, permanently mounted on steel skids, and can be moved about from well to well as a unit. All that is required at the well is a suitable foundation of concrete or timber and a supply of natural gas and water if an internal-combustion engine is used, or an electrical connection if the unit is motor-driven. A modern pumping unit is mechanically well designed to give trouble-free efficient service. Every part is proportioned to carry the load imposed, with an appropriate safety factor. Careful attention is given to the stresses imposed on supporting structural members and to the mechanical details of shaft and bearing sizes, and gear ratios to provide proper speed reduction.

A great deal of attention has also been given to improvements in the design of oil-well plunger pumps. For deep-well service, long steel plungers are used—machined and polished to fit snugly within the polished surfaces of the working barrel. Pump valves and seats are of special steels, selected to give long service and to resist abrasion and sand scouring. Special attention is given to maintenance of proper clearance between the polished surfaces to reduce leakage under high fluid pressures.

Spring-pole drilling; otherwise known as "stomping down a well" (API photo).

A "borer," as first drillers were called, at work inside an early cable-tool rig (API photo).



For wells which require frequent pump repairs, an "insert" type of pump may be used which permits removing all wearing parts of the pump to the surface on the sucker rods; so that it is seldom necessary to "pull" the well tubing. Some types of pumps are especially designed to handle sandy production with minimum wear. A gas "anchor" below the working barrel of the pump prevents much of the gas which enters the well with the oil from getting into the pump.

Rod-operated plunger pumps become progressively less efficient as the depth from which fluids must be lifted increases. This results from the elastic behavior of the sucker rods, which are often subjected to stresses approaching the yield point of the metal. Loss of length of effective stroke of the pump plunger, as a result of elastic stretching of the rods, apparently limits the depth from which fluids may be lifted with this type of pump. This reduced efficiency can be offset to some extent by proper counter balancing and by adjusting the timing and length of the plunger stroke; but, under best conditions, the limiting depth for acceptable performance of rod-actuated pumps appears to be about 10,000 ft. Rod breakage resulting from imposition of excessive loads is also an important factor tending to limit the depth at which plunger pumps may be efficiently operated. Deep installations require use of rods made of alloy and specially heat-treated steels of high tensile strength and yield point, and protection against rod-metal corrosion.

Application of engineering principles to operation of rod-actuated plunger pumps has encouraged the use of rod dynamometers, fluid-level indicators, and other devices for measuring rod stresses and analyzing rod and pump performance. Such instruments are helpful in adjusting counterbalances, and length and timing of stroke, to secure maximum efficiency.

Engineering studies have indicated that the efficiency of rod-actuated plunger pumps may be improved by use of long, slow plunger strokes rather than short rapid strokes. This knowledge has encouraged the development of long-stroke devices and speed-reducing mechanisms in application of power to pumping wells. Some long-stroke pumping machines use pneumatic or hydraulic force to actuate a piston in a vertical cylinder mounted over the well head. The polished rod and column of sucker rods are suspended from the vertical piston rod. Plunger strokes as long as 31 ft are possible with one of these devices, with as many as 10 strokes per min, thus providing 310 ft of plunger travel per minute.

Multiple-Pumping Systems: As the rate of production declines, a separate power plant at each well is likely to result in excessive unit production costs. Early in the development of applying power to pumping wells, it was recognized that some system whereby all wells of a group could be operated from a conveniently situated central power plant would be advantageous. This was first accomplished in the older fields where wells were shallow and closely spaced. From the central power plant—equipped with a gas engine or electric motor of suitable size—"shackle lines" or "pull lines" of steel rods or cable extend out to the individual wells. These are given a horizontal, reciprocating motion by one or two rotating eccentrics at the central power plant, driven by belting or gearing from the engine or motor. The pull lines are supported on "rockers" or other simple structures, so that they are above ground level and may reciprocate horizontally with minimum frictional losses. Each well is equipped with a pumping "jack" to which the pull line is attached and from which the polished rod and column of sucker rods in the well is suspended. The jack, usually of triangular form and supported in a vertical position at the well head, has the function of changing the horizontal reciprocating motion of the pull line to the vertical reciprocating motion of the sucker rods. The pull lines are always in tension; however, the tension is greater on the upstroke of the sucker rods than on the downstroke. Each pull line receives its power impulse in turn as the eccentrics at the central power plant rotate, and connections are so made that the sucker rods in some of the wells are given their upstroke as others are on their downstroke. This makes possible a balancing of loads so that the weight of the descending columns of sucker rods in some of the wells actually helps lift sucker-rod columns in other wells of the group on their upstroke. Power is thereby saved and lifting costs reduced.

The number of wells which can be operated from one central power plant depends upon their depth, rate of production, and upon the spacing of the wells and the character of the surface terrain. Sometimes as many as 40 wells are operated from one central power plant. Because of their low operating cost, though often primitive in construction, many of these multiple-pumping installations in the older fields are still used. The production of individual wells may be so small that they are operated only intermittently as oil accumulates. Multiple-pumping systems of this type are not well adapted for use in the deeper wells drilled today, so that they are becoming obsolete.

Rodless Plunger Pumps: Most of the difficulties attending use of sucker rods in operating plunger pumps in oil wells are avoided by using a system of pumping in which the pump is actuated by a circulating fluid under pressure. Pressure is imposed on the circulating power fluid—usually some of the oil produced by the well served—by a triplex surface pump; and the high-pressure oil is transmitted down to the pump in the well through a separate and different column of pipe from that through which the well fluid rises to the surface. The pumping "engine" in the well is directly connected to the pump plunger. Both reciprocate under the influence of the circulating power fluid, and the spent power fluid is added to the oil produced by the well for return to the surface. One surface pump may produce sufficient high-pressure power fluid to operate several nearby pumping wells, so that the advantages of multiple-power application may be practically realized.

The best known pumping system of this type is that developed by C. J. Coberly, now marketed by the Kobe Co. This system of pumping has the additional advantage that the pump in the well may be quickly circulated to the surface for inspection and repair and returned to its operating position by the power fluid. This system of pumping also has many other advantages, and is applicable to wells of any depth.

Another type of pump used in oil-well service which requires no sucker rods is a multi-stage centrifugal pump operated by a special type of electric motor which is submerged in the well fluid and direct-connected to the pump. The Reda pump, of this type, with 133 rotors, has been used to pump fluid from wells 6,500 ft deep. This pump is notable for its large capacity, which ranges as high as 5,000 b/d from wells 6,500 ft deep. There are no moving parts at the surface; and, within the well, all moving parts are contained within the casing which encloses the pump and motor. The pump-and-motor unit is suspended in the well fluid on a column of tubing through which the fluid flows to the surface. Electric power is transmitted down to the pump motor in the well through an armored and insulated cable, clamped at intervals to the tubing.

Pneumatic Methods of Lifting Oil from Wells: Wells which flow their own production do so by the expansive force of natural gas, intimately mixed with the oil as it moves into the wells from the reservoir rock. When wells no longer produce enough gas, or gas under sufficient pressure, to continue natural flow, the well fluids may continue to reach the surface by flow methods with the aid of additional gas circulated down the well from a surface source. Compressed air was used for this purpose during the early years of oil production; later, air was almost entirely superseded by compressed natural gas. During the early '20's, a system of production was developed in the California fields which involves trapping of gas from the fluids produced by the wells, passing the gas through a natural-gasoline recovery plant, compressing the "dry" gas, and injecting it through tubing into the wells to assist in lifting additional oil. This "gas-lift" system of production has found wide use since that time, and may serve as a cheap and efficient method of lifting oil through a certain period of the productive life of many fields.

In early applications of the gas-lift method of lifting oil, compressed gas was injected into the well through the side outlet of the casinghead, so that it flowed down through the annular space between the oil string and a flow string of tubing through which fluids were ejected to the surface. The lower open end of the flow string was suspended well below the nat-

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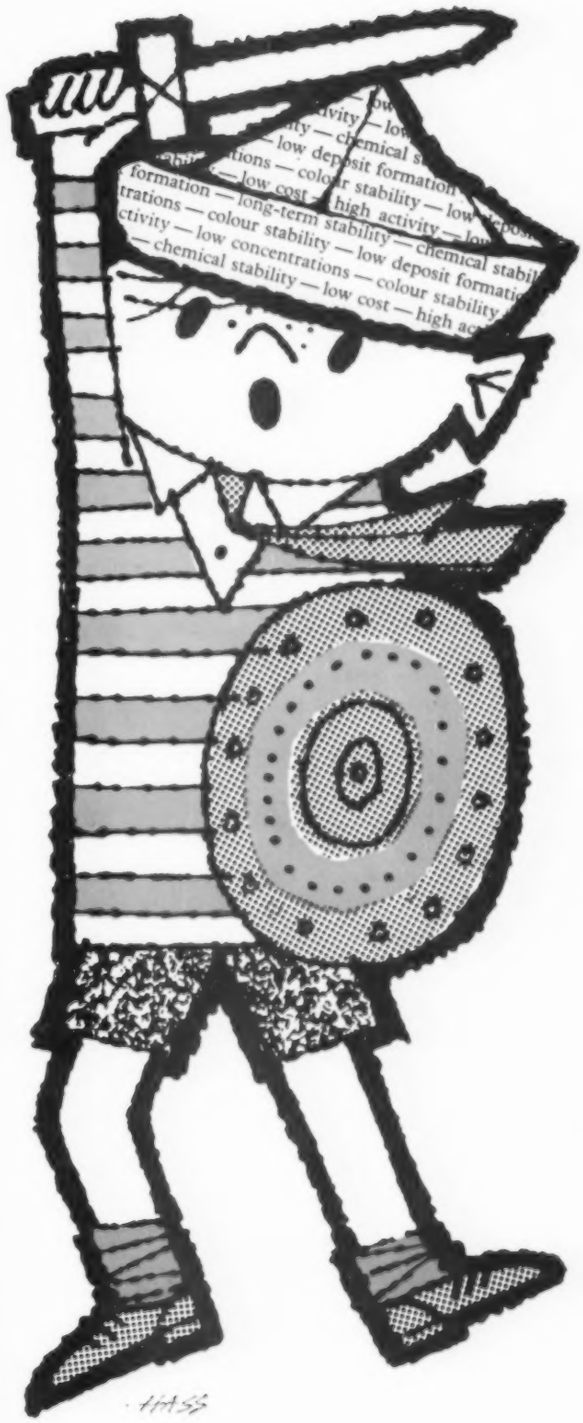

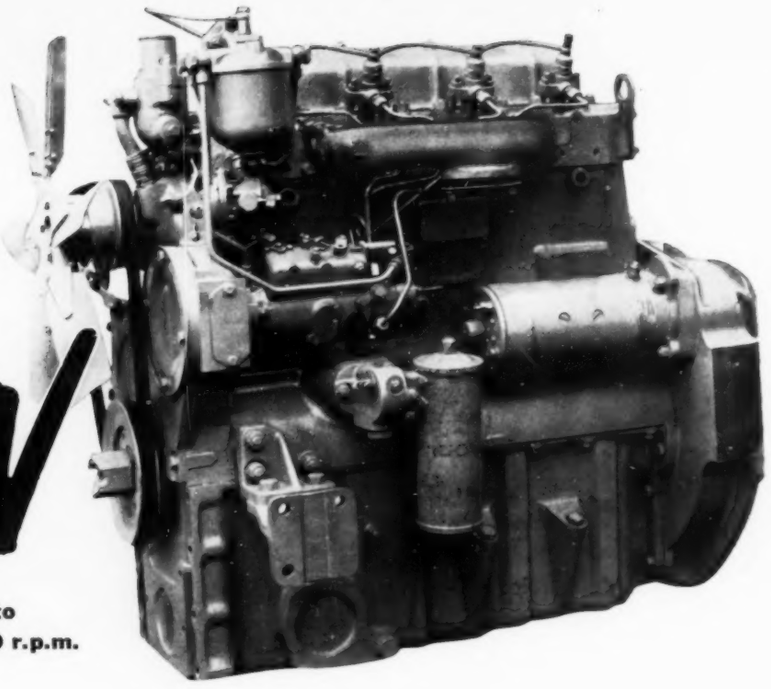

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						1000	1200	1500	1800	2000	2400	3000	3600
Four 99(I)	4	3	3½	99	A	10	13	17	21	24	29	35	—
					B	11	14	19	23	27	32	38	—
					C	11	14	19	24	28	33	40	42
P3/144(I)	3	3½	5	144	A	17	20	26	30	33	—	—	—
					B	18	22	28	33	36	—	—	—
					C	19	23	29	34	37	42	—	—
P4(I)	4	3½	5	192	A	22	27	34	40	44	—	—	—
					B	24	30	37	44	48	—	—	—
					C	25	31	38	46	50	55	—	—
Four 270D(I)	4	4¼	4¾	270	A	33	39	47	53	57	—	—	—
					B	36	43	52	58	62	—	—	—
P6(I)	6	3½	5	288	A	34	41	51	60	65	—	—	—
					B	37	45	56	66	72	—	—	—
					C	38	46	58	69	75	83	—	—
R6(I)	6	4	4½	340	A	38	46	58	67	69	—	—	—
					B	41	51	64	74	76	—	—	—
					C	44	54	68	81	89	102	—	—
S6(I)	6	4⅜	5	450	A	49	62	80	96	105	—	—	—
					B	54	68	88	106	115	—	—	—
					C	56	70	91	109	119	—	—	—

REMARKS A. Denotes continuous rating to BS 649: 1958 conditions (85°F. and 29.5 hg). For every 10° above 85° F. this rating should be reduced by 2% and for every 1000 ft. above 500 ft. altitude the rating should be reduced by 3½%.
B. Denotes one hour rating to BS 649: 1958 conditions. See notes above re de-rating.
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ural level of fluid in the well, but the injected high-pressure gas depressed the fluid level to that of the open end of the flow tubing, so that the gas entered the flow string with the well fluid—expanding rapidly as it flowed to the surface. Sometimes the direction of flow was reversed—high-pressure gas flowing down through a column of tubing, mixing with the oil, and flowing back to the surface through the annular space.

Later improvements in gas-lift design have involved use of small spring-actuated valves in the wall of the flow tubing, through which gas may enter the tubing at various depths, aerating the column of oil in the flow tubing—thus reducing the pressure necessary to start the lift in operation after an interruption in service.

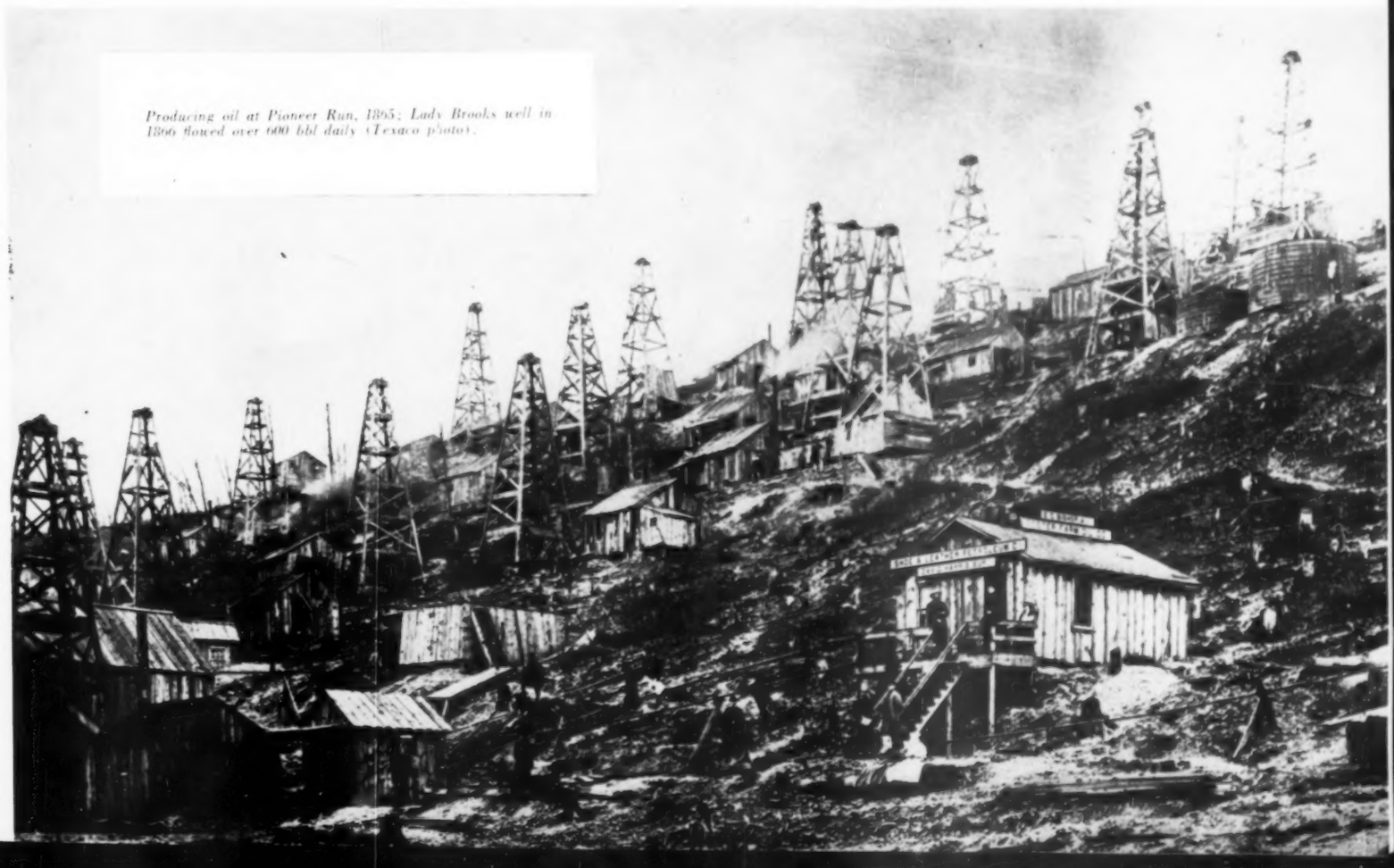
Intermittent-flow systems have also been devised which permit use of gas lift for rates of production below that at which continuous gas lift will operate efficiently. In fact, intermittent-flow methods permit use of pneumatic lifting throughout the entire producing life of a well, without ever resorting to use of mechanical pumping devices.

Another useful device for lifting oil by pneumatic means, after natural flow or continuous gas lift are no longer efficient, is the plunger lift. This comprises a free-traveling plunger which is equipped with a balanced valve. The plunger fits snugly against the inside wall of the flow tubing. With the valve open, the plunger descends through accumulated fluid in the flow tubing and comes to rest in a cushion seat near the lower end of the flow tubing. Accumulating gas below the plunger then causes it to rise to the surface. With the valve in the plunger closed, all oil above the plunger in the flow tubing is thus lifted to the surface, where it is discharged through an oil-and-gas separator into storage tanks. After discharging a load of oil, the plunger again falls to the bottom of the tubing for another cycle. If necessary, the plunger lift may be assisted by gas circulated under pressure down to the bottom of the well from a surface source. The lift may automatically make several hundred strokes per day, and capacities range up to 600 b/d. Only 300 to 500 cu ft of gas is needed per barrel of oil produced for each thousand feet of lift. For depths of less than 3,500 ft, the gas pressure used need not exceed 100 psi.

Methods of Increasing Recovery of Petroleum from its Reservoir Rocks: During the first few decades of oil and gas production, the primitive recovery methods employed were inefficient and capable of producing only a small percentage of the oil actually present in the reservoir rocks. Producers had only a vague understanding of the natural forces and conditions within the oil and gas reservoirs which influenced recovery. In many cases, it appears that as little as 10% or 20% of the oil actually present was recovered. About 1910, the US Bureau of Mines began a series of investigations of conditions influencing oil recovery. The bureau's publications focused attention on the problem of improving recovery efficiency, and soon several oil companies and universities began programs of research designed to improve understanding of the conditions influencing oil recovery and to explore possible methods of improving recovery efficiency.

The early research projects were qualitative in character; they were designed primarily to delineate the factors influencing recovery, and to suggest possible ways of increasing recovery. It was recognized that several natural forces were operative in oil reservoirs—tending to expel the oil and gas; and that these differ in their effects and are opposed by certain other natural retentive forces related to the lithology of the reservoir rock—particularly its porosity and permeability and the character of the pore openings. Also the viscosity, density, and surface tension of the reservoir fluids were found to have an important influence on drainage efficiency. Connate water in the reservoir-rock pore spaces and the relative permeability of the reservoir rock to oil, gas, and water were also found to be important in limiting recovery effciency.

Later research programs have been designed to measure quantitatively the effects of these variables, and efforts have been made to formulate the factors involved, so that percentage recovery predictions can be made under varying conditions. Knowledge of these matters has suggested ways of completing and operating wells to stimulate production. Research work on improved recovery methods, which began about 1910, is still continuing, and each year the more progressive oil producers and research agencies are spending many millions of dollars on production research. Over the years, this research has been notably successful, so that the percentage oil recovery is today two or three times what it was earlier.



Producing oil at Pioneer Run, 1895; Lady Brooks well in 1896 flowed over 600 bbl daily (Texaco photo).

Well-Completion Methods: Early producers were content merely to drill a hole through the producing formation and take such oil and gas as entered the well unaided, by natural flow or by mechanical pumping. Now, careful attention is given to methods of well completion which will prevent influx of water, sand, and detrital material with the oil and gas, and to techniques which can be applied to increase the permeability of the reservoir rock immediately surrounding the walls of the wells.

Sand control is important in reservoirs where the producing formations are poorly consolidated and tend to cave and accumulate in the wells. Wells producing from unconsolidated or semiconsolidated formations are equipped with perforated and screened liners through the producing formations. Gravel "packs," surrounding the screen pipe, further assist in restraining influx of fine sand. Unconsolidated sand which tends to cave into the wells can also be treated with a plastic which develops an adhesive bond between the sand grains—restricting caving tendencies, yet leaving sufficient permeability to allow oil to pass through into the well.

Formation of well cavities by enlarging the bore of the well, where it passes through the reservoir rock, reduces energy losses in the critical zone surrounding the wall of the well—tending to increase the rate of production of the well, and improving recovery efficiency. If necessary to prevent caving, well cavities may be filled with gravel or coarse sand which offers little resistance to flow of reservoir fluids. Well cavities may be formed by hydraulic methods in loosely consolidated material, or by explosives in harder formations. Mechanical reaming devices are also available for this purpose.

The use of nitroglycerin as a means of stimulating production of wells was practiced during the early years of the oil-producing industry, and is used to some extent today. Torpedoes containing from 10 to several hundred quarts of nitroglycerin are lowered into the well and supported in the interval where a cavity is to be formed, tamped with water or sand, and detonated electrically or with a squib. The powerful explosive pulverizes the wall rocks, leaving a pear-shaped cavity several feet in diameter after the detrital material has been bailed out. In addition, fractures are formed, extending outward from the well cavity through the surrounding reservoir rock. By this means, new drainage channels are formed through which fluids may flow into the wells with lessened resistance, and the rate of production of the well may thus be substantially increased.

Development of gun perforators of the shaped-charge type suggests another method of applying explosives in increasing the permeability of oil reservoir rocks exposed in the walls of wells. Powerful shaped charges of large size may be used to form horizontal holes in the walls of wells where they penetrate the oil-bearing strata. These holes may extend several feet into the wall rocks, thus reducing pressure losses in the critical zone immediately surrounding the walls of the wells—thereby increasing recovery efficiency.

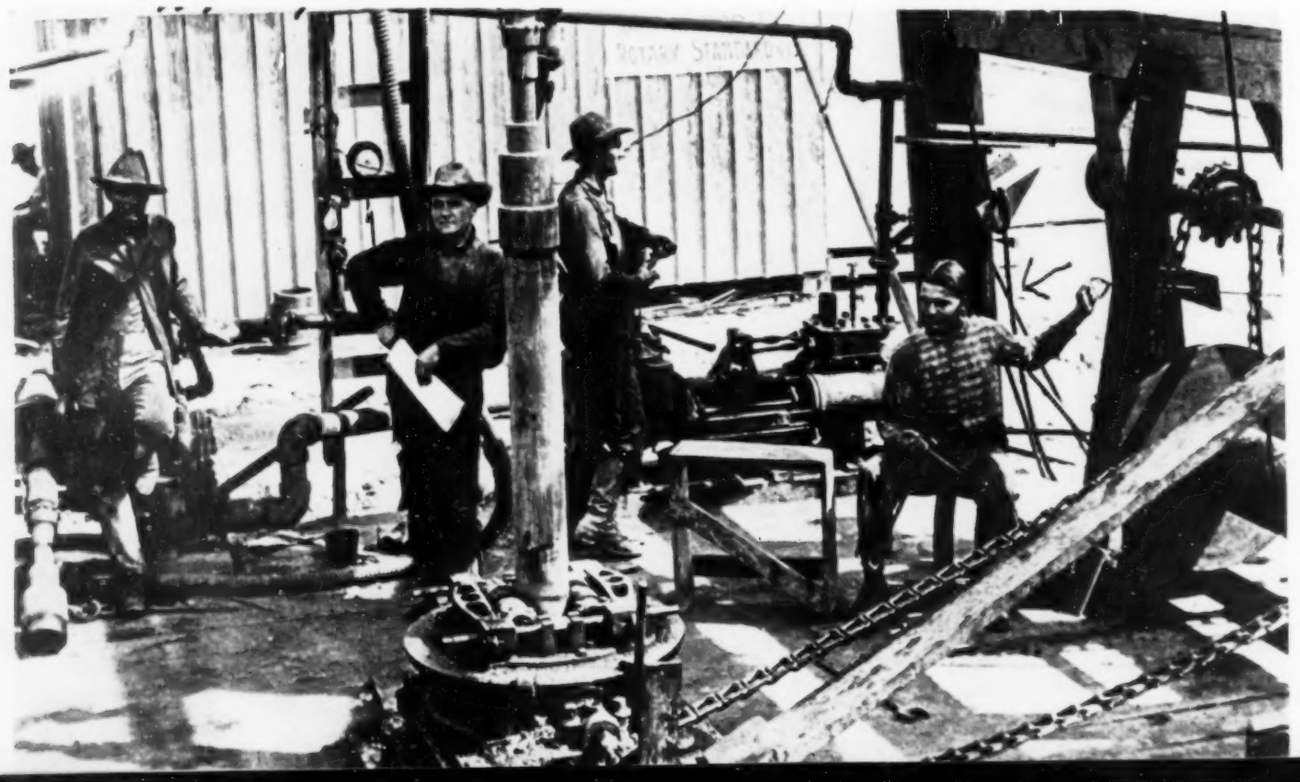
Limestone reservoir rocks may be treated with hydrochloric acid, which dissolves carbonate minerals, forming cavities and enlarging drainage channels, and generally increasing the porosity and permeability of the reservoir rock about the wall of the well. The rate of production and ultimate recovery are thereby increased. The acid may be injected under pressure so that it is forced into the reservoir rock for many feet from the wall of the well. After treatment, the spent acid drains back into the well and is removed to the surface.

One of the most effective methods of stimulating oil recovery is a comparatively recent development known as "hydraulic fracturing." This involves forcing a liquid —usually oil or water—into the reservoir rock through the wall of a well, under sufficient pressure to displace segments of the reservoir rock and form crevices which extend for a considerable distance outward from the wall of the well. The pump pressure applied to the injected fluid may be sufficient actually to lift the formations overlying the reservoir, opening horizontal crevices along bedding planes; and, in some cases, it appears that vertical fractures are also formed, connecting bedding planes. Sand particles, suspended in the injected fluid, follow the fluid into the formation fractures and serve as a propping agent to prevent them from closing again when pressure is released. New flow channels for oil and gas, thus formed and maintained, usually result in an increased rate of production and greater ultimate recovery.

Methods of drilling branch holes at an angle from conventional wells have lately been developed. Under favorable conditions, several holes may be drilled in the plane of the dip of the producing formations in different directions, each reaching perhaps a hundred feet or more from the axis of the well. These "drain holes," as they are called, add hundreds of square feet of drainage surface to that normally provided by a vertical well, thus increasing oil-drainage efficiency. Drain holes may be cased with screen pipe or filled with gravel so that they do not cave.

Secondary-Recovery Methods: In an earlier section, it was explained that the inefficiency and primitive character of earlier methods of flowing and pumping wells resulted in a large percentage of the

First rotary drilling job at Spindletop (Humble Oil & Refining photo).



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petroleum actually present in our older fields being left drained of its natural energy, and not economically recoverable by ordinary production methods. Many billions of barrels of oil have thus been left unrecovered in fields exploited up to the present time. This unrecovered oil poses a challenge to our production technologists to devise new, more efficient recovery methods which will permit production of at least a part of the oil left behind in partly drained oil and gas reservoirs. Our technologists have been fully aware of this situation, and for 50 years or more have been seeking new and improved recovery methods which might enable producers to secure a second "crop" from our older fields. A variety of methods have been proposed, some of which have been successfully demonstrated in field operations.

A vast amount of laboratory research has also been directed toward development and improvement of secondary-recovery methods. Application of improved recovery methods has also been greatly aided by modern methods of securing reservoir data. Stratigraphic and lithologic data are assembled through the entire thickness of the reservoir rock as the well is drilled, by taking cores and removing them to the laboratory for determination of porosity, permeability, and fluid content, and by use of various logging technics. Formation tests may also indicate the productivity of different formational intervals.

Use of Vacuum in Stimulating Oil Production: The oldest of the secondary-recovery methods involves application of vacuum to wells to increase the differential pressure between the producing formation and the well. In this method, a vacuum pump is connected to one of the side outlets of the well's casinghead, and continued operation of the vacuum pump gradually reduces pressure within the well and the surrounding reservoir rock—causing additional gas and oil to flow into the well. However, the reduction of pressure within the well is practically limited to about 12 psi, and the additional oil thus secured is usually scarcely enough to pay the additional cost. However, this pressure reduction is often sufficient to release a large volume of gas from solution in the reservoir oil, and this gas is often rich in light hydrocarbon vapors, and is a profitable source of natural gasoline which may be removed from the gas in surface recovery plants. The vacuum process was formerly widely used, but today is almost obsolete because of its high cost and because better recovery methods have been developed.

Gas-Injection Methods of Increasing Recovery of Petroleum from Partly Depleted Reservoirs: Early in the oil-producing industry, it was recognized that in many fields expanding natural gas was responsible for production of much of the oil and that, as this gas energy became depleted, oil production declined. It was, therefore, natural that producers should seek to restore production in depleted fields by forcing natural gas under pressure back into the reservoir rocks. This was demonstrated successfully in one of the Pennsylvania fields about 1890, but it was not until 1903 that the method was applied on a field scale in a field near Marietta, Ohio, by I. L. Dunn. For a time, the method was known as the Dunn or Marietta process. Compressed air has also been used instead of natural gas, but air has certain disadvantages not shared by natural gas.

One can visualize three different methods of applying gas-injection technics to increase recovery from oil reservoirs. In "gas driving," the gas is injected into certain wells reserved for this purpose, and is caused to flow through the reservoir rock to other nearby wells which are pumped for oil—thus driving some of the residual oil ahead of an expanding body of gas into the recovery wells. In another method, which we may call "pressure restoration," all wells are shut in for a time while compressed gas is injected into certain selected wells until the field pressure is restored to approximately the initial reservoir pressure. Much of the gas is forced to enter into solution in the residual oil, so that conditions which initially caused the wells to produce are to a considerable extent restored. Then all of the wells are reopened for production of a second "crop" of oil. The method may be repeated as long as it proves profitable. The third gas-injection method is called "pressure maintenance." Here gas is injected into certain wells—usually near the crest of the structure—early in the life of the field, so that the initial field pressure is substantially maintained and is not permitted to decline until the oil is depleted. High-pressure gas stored in the oil-drained pore spaces of the reservoir may then be produced. Of these three gas-injection methods, gas driving and pressure maintenance have been widely applied in the oil-producing industry, and have proved to be profitable in many cases.

Gas-injection methods have the advantage that they use nature's method of moving oil through reservoir rocks, and that they do not damage the reservoir in any way. Such oil as still remains unrecoverable by gas-injection methods may still be recovered by other methods.

Water-Flooding Methods of Secondary Recovery: In water flooding, we seek to recover the residual oil by injecting water under pressure into selected wells, forcing the water by applied pump pressure to enter the reservoir and flow toward other nearby wells which are pumped for oil in the usual way. The injected water is encouraged to displace the residual oil by con-

Hauling drilling equipment along a mud road from Seminole City, Okla., in the 1920's (SONJ photo).

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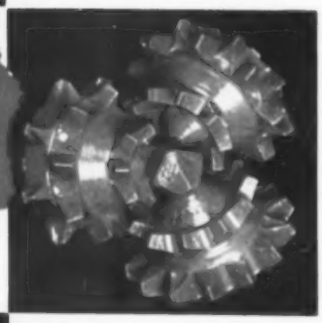

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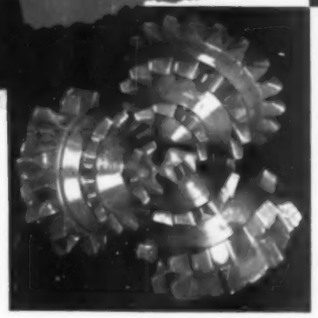

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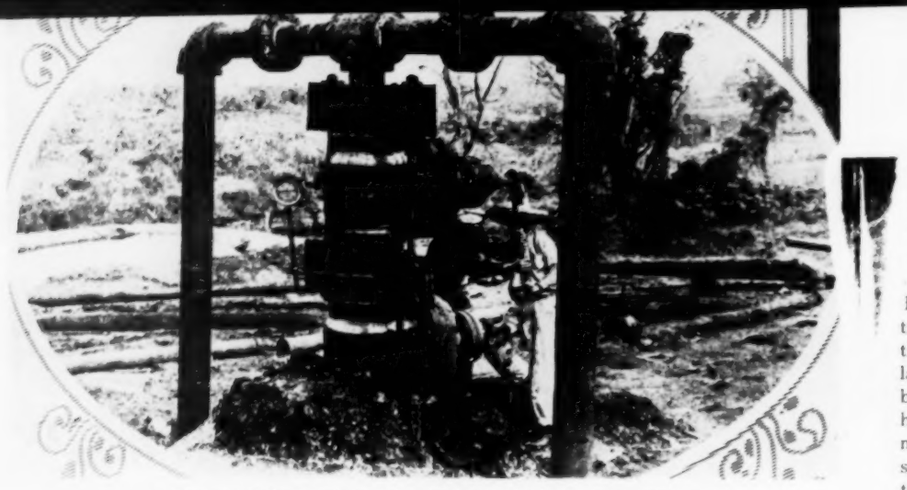


Sinclair "gusher" well head in the Panuco field, Mexico, around 1927; Casing is held down by a steel pipe arch.

centrating the oil ahead of the slowly advancing water-oil interface in the form of a "bank" which eventually reaches the recovery wells, and is produced. After the accumulated oil has been produced, the flood water enters the recovery wells, production of oil rapidly diminishes, water injection is stopped, and the flooded area is abandoned. Such oil as still remains unrecovered in the reservoir rock is surrounded by residual water, and must be regarded as forever lost and not recoverable by any known method.

Water flooding, when properly controlled, may be highly efficient, recovering perhaps 60% or more of the residual oil. For this reason, it has been widely used in the oil-producing industry. One of the most promising of the secondary-recovery methods, a great deal of research has been directed toward improving its efficiency. The location of injection wells and producing wells must be carefully selected—with special regard to stratigraphy, structure, and lithology of the reservoir rock, and distribution of the residual oil. Water-injection pressures and rates must be carefully controlled. The water employed must often be subjected to chemical treatment to remove impurities which tend to clog the pores of the reservoir rock. Research workers have sought chemical reagents which might be added to the injected water to promote release of adherent oil, and some success has been attained in this direction. Water-flooding technics are sometimes combined with systems for disposing of salt water produced with the oil. After the water has been separated from the oil and chemically treated, it can be reinjected into the producing reservoir, at downdip locations, to aid in maintaining reservoir pressure and in producing additional oil.

Other Fluid-Injection Systems: Laboratory research and experimental field tests have indicated that highly efficient recovery of residual oil may be secured from partly depleted reservoirs by injection of gases rich in low-boiling hydrocarbon vapors or low-boiling liquefied hydrocarbons such as butane and propane. These light hydrocarbons enter the reservoir rock and, being miscible with the residual oil, reduce its viscosity and alter its surface tension, and thus promote release from the reservoir rock. The mixture moves through the reservoir rock from injection to recovery wells and, after removal to the surface, the light hydrocarbons again assume vapor form, and may be separated from the heavier liquid oils and injected again for production of additional oil. Laboratory research indicates that recoveries exceeding 90% of the residual oil may be secured by this process. Several field tests of the method are currently under way.

Other proposed fluid-injection systems involve establishing a "bank" of miscible light hydrocarbons behind a "bank" of accumulating residual oil and then using dry gas or water as a driving agent to move the oil into the recovery wells. Another method proposes use of immiscible liquid carbon dioxide as a driving agent. The carbon dioxide, produced at the recovery wells in vapor form, can be liquefied by applying pressure and again reinjected.

Secondary-Recovery Methods Involving Application of Heat: Electric resistance heaters, placed in wells at the level of the reservoir rocks, are capable of increasing the temperature in the critical drainage zone immediately surrounding the walls of the wells—thus reducing the viscosity of the oil and its flow resistance. Live steam may also be used for this purpose.

Another thermal method, which has been experimentally tested in several American fields during recent years, involves *in situ* combustion of a part of the residual oil in the reservoir rock. Gas is injected into certain wells, ignited, and combustion supported by injected air or oxygen. The combustion zone progresses slowly through the reservoir rock from the injection wells toward surrounding recovery wells. The heat developed vaporizes, or so reduces the viscosity of the residual oil that much of it is driven ahead of the advancing fire zone into the recovery wells—leaving behind only sufficient heavy oil to support combustion.

Oil Mining: Much of the inefficiency experienced in applying oil and gas recovery methods through wells results from inability of the producer to obtain accurate information concerning the reservoir rock, the distribution of fluids, and the conditions immediately surrounding the wells. A more efficient method of securing production of residual oil from partly drained reservoirs involves driving mine openings from the surface into and through the reservoir rock or into the immediately adjacent formations. Mine shafts permit access to the reservoir rock; and galleries or "drifts," driven horizontally or at a slight inclination from the horizontal, directly through the reservoir rock, open up comparatively large drainage surfaces. Or production may be taken through many closely spaced bore holes drilled from drifts in the cap rock immediately overlying the oil-producing strata. Drainage into the mine "drifts" through the reservoir rock is more effective because the fluids move along parallel lines of flow rather than through converging channels toward the walls of wells.

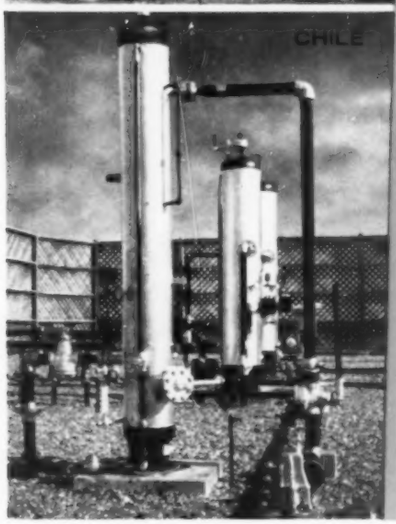
All the problems of oil mining have been solved by practical application on a large scale, and results have indicated a much higher recovery of residual oil than by other secondary methods. Oil-mining operations have been extensively used in the Pechelbronn field in Alsace, with substantial recoveries over a period of many years. It is also possible to combine other secondary-recovery methods with oil mining; e.g., gas driving or water flooding between parallel mine drifts.

In the mining methods suggested in the foregoing paragraphs, oil is drained from the reservoir rock *in situ*, removing to the surface only so much of the reservoir rock as is necessary to create the mine openings. Another procedure is possible, particularly for outcropping or near-surface deposits of oil sand. After stripping off the overburden, the oil sand may be mined with power shovels and removed to nearby treatment plants where the oil may be removed from the sand with recovery of almost 100% of the oil. The process employed for separation of the oil from the sand is one in which the crushed and disaggregated sand particles are washed with hot water or with a dilute water solution of sodium carbonate. In some parts of the world, there are large near-surface deposits of "tar sand" which can be mined, and the oil recovered in this way. One notable deposit, which in future may yield many billions of barrels of oil, occurs along the Athabasca River in the province of Alberta, Canada. END

WORLD PETROLEUM PRODUCTION, 1859 TO 1958

Years	Gross Production (Thousands of Barrels)
1859-1869	29,821
1870-1879	119,979
1880-1889	409,426
1890-1899	1,033,857
1900-1909	2,187,520
1900-1909	2,187,520
1910-1919	4,269,270
1920-1929	10,582,817
1930-1939	16,617,792
1940-1949	26,501,888
1950-1958	47,056,279*
Cumulative Production, 1959-1958	108,808,649

* Estimated for 1958.



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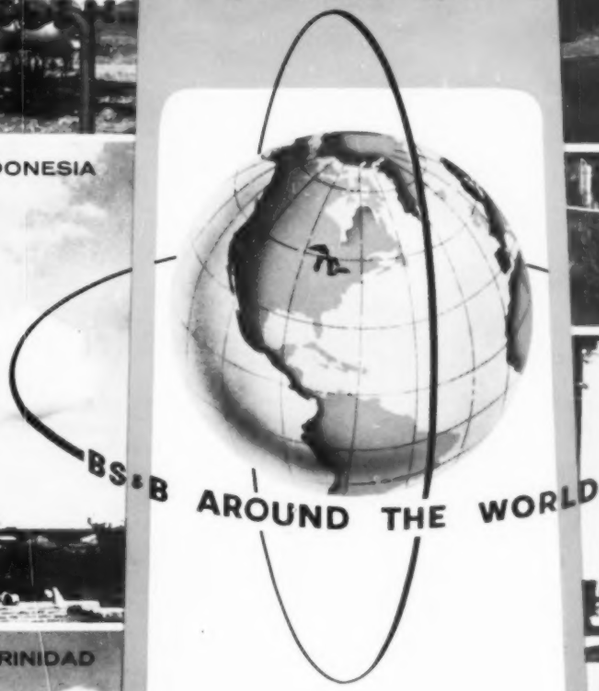

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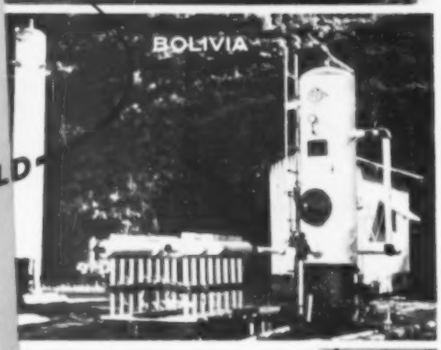

BJ Oil Tool

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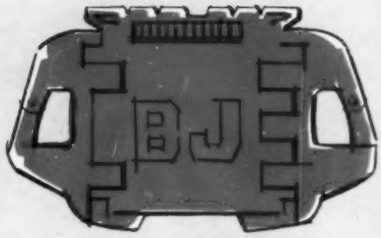

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Elevators

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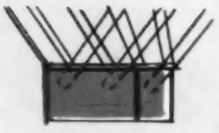
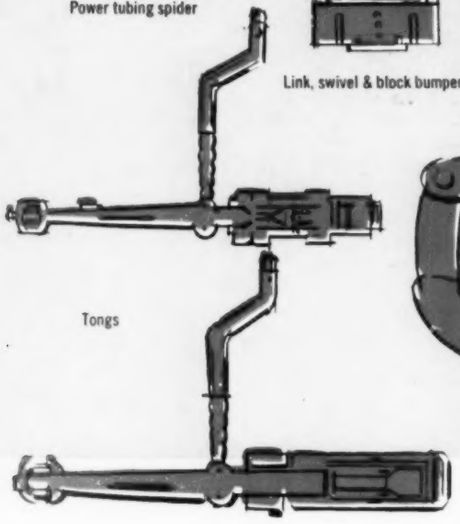


Scratchers



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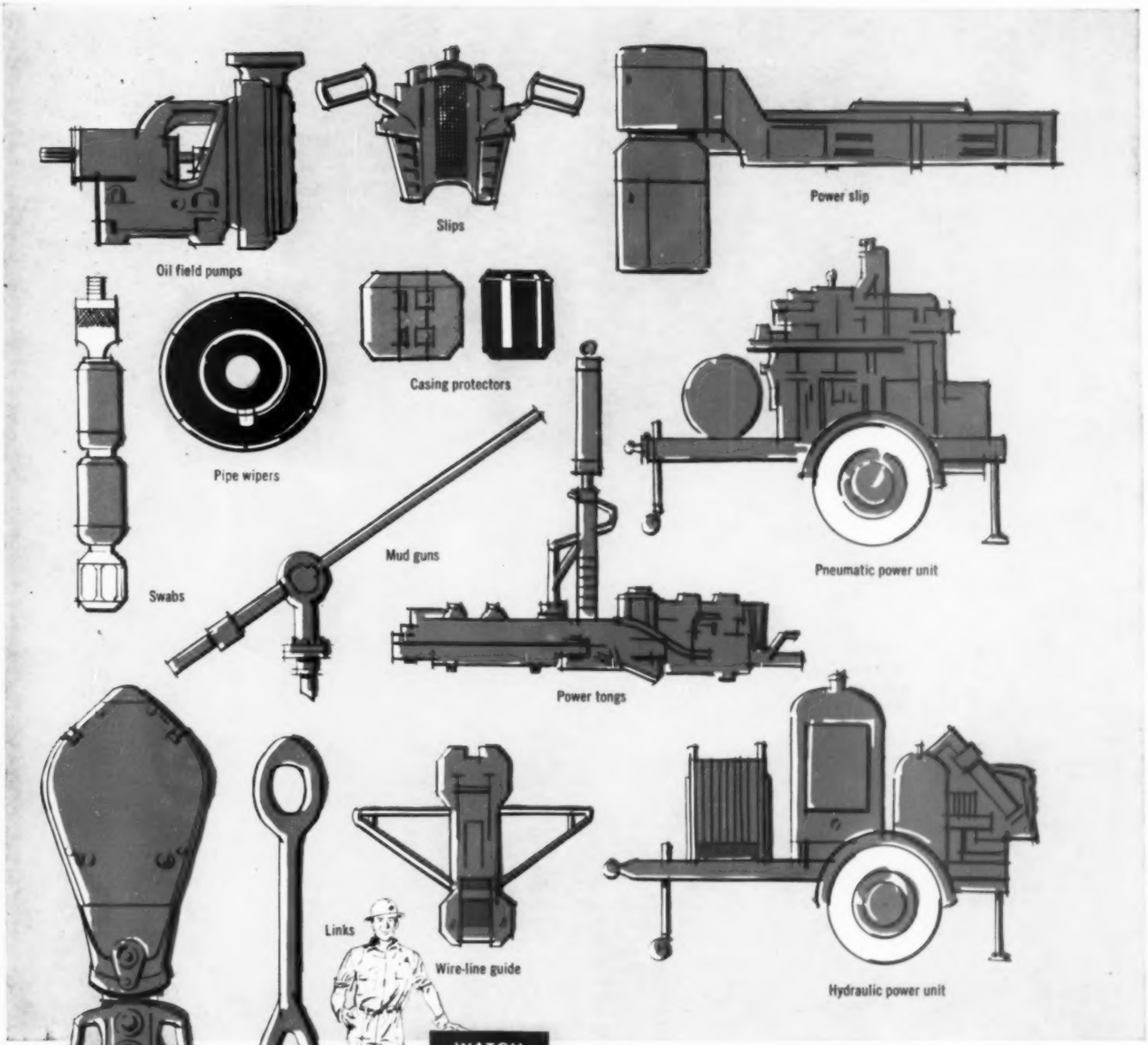

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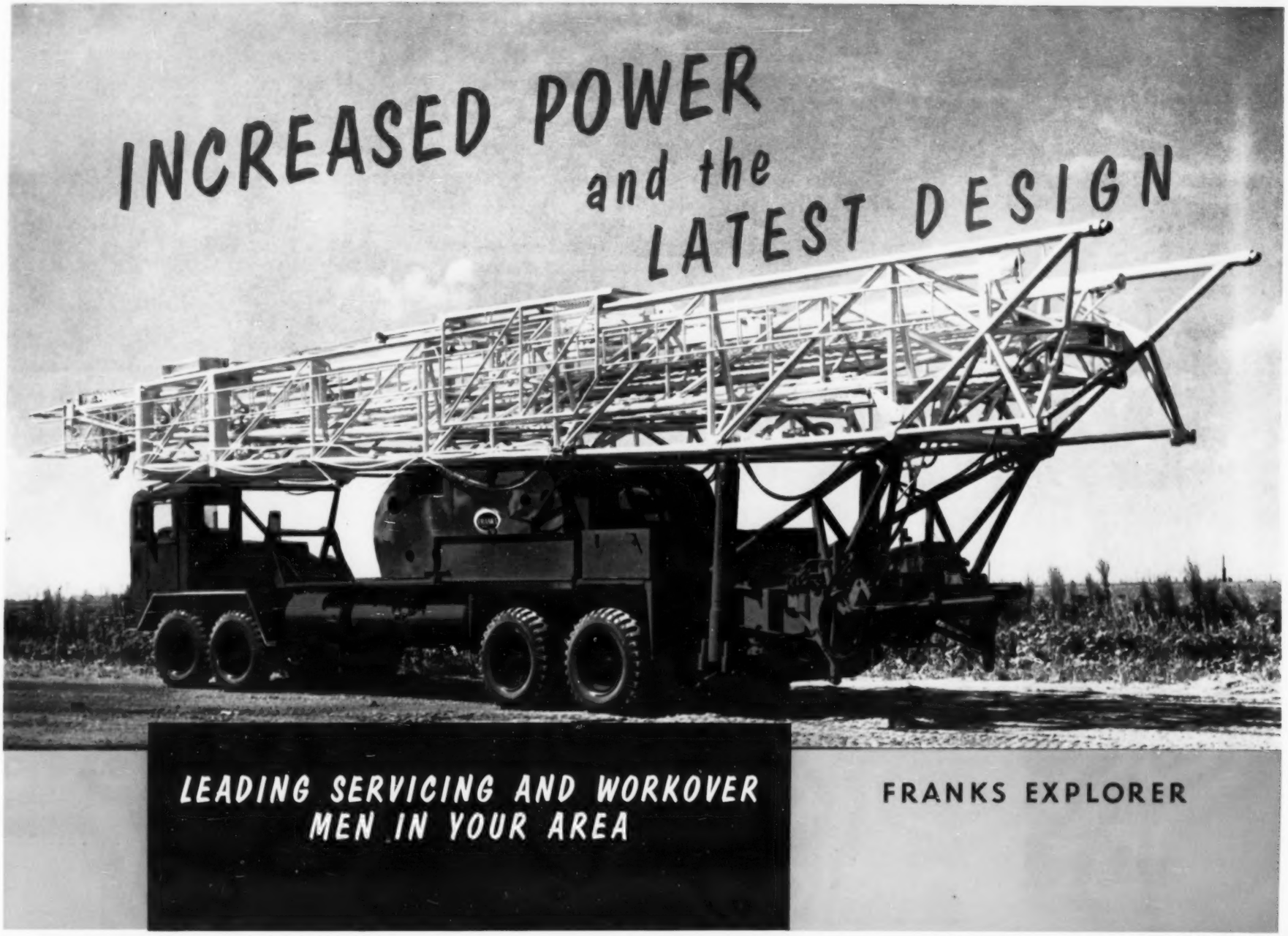
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A North Dakota filling station around 1916 (Standard of Indiana photo).

Metal barrels behind Continental Oil's warehouse, Butte, Mont., 1880.

MARKETING...from coal oil to the petroleum molecule

by V. B. Guthrie[1]

Shortly after the turn of the century, scientists with the oil companies learned how to transform the properties and characteristics of the crude oil and its fractions they were processing in their refining operations. It had earlier been discovered in the laboratories that the hydrocarbon molecules which make up crude petroleum could be altered in size and weight, and in the arrangement of their hydrogen and carbon atoms. The first refinery operation putting this knowledge to practical use was to break up, or "crack," the molecules in gas oil into smaller molecules in the manufacture of gasoline. This was just prior to World War I.

Other processes embodying the concept of changing the structure of the molecule came along later, viz., isomerization, polymerization, reforming, to mention only a few. Through the use of these processes, refiners have been able to increase the yield of a desired product from the crude put through their stills, as with cracking to increase the gasoline yield. They are also able to make entirely new commercial products from crude petroleum, as new markets have developed. By means of these processes, refiners have also improved the quality of their established products.

Today, refiners make and market products of the desired composition to meet specific utilization requirements. In effect, the oil companies market a wide range of petroleum molecules of selected properties. The petroleum molecule, in symbols and in such phrases as "Nature's Miracle Molecule," is already finding its way into some oil-company promotion and sales programs.

This revolutionary change in refining methods was not the only factor which brought about the dramatic increase in the use of petroleum in the second 50 years of the petroleum industry. The coming of the automobile created the largest single market for petroleum fuels and lubricants. The general industrial expansion taking place in these years also increased the petroleum markets. There was a steady growth in the population. Oil replaced coal in a good portion of the space-heating market. New flush oil fields were discovered, starting with Cushing in Oklahoma in 1912, which made crude petroleum available in abundant quantities for the fast-growing petroleum markets.

It was more than a coincidence also that the great expansion in the use of petroleum followed the dissolution by the courts in 1913 of the early Standard Oil monopoly. The Standard of those days was ruthless in its competition, and the other oil companies which stood up under it were hardy enterprises. The competition was for existing markets, not to find new uses for petroleum.

The courts broke up the original Standard Oil combine into 23 oil companies which, in effect, were told by the courts to stand on their own feet. Real competition developed among some of these concerns, and between them and other oil companies. Thousands of independent marketing companies started in business to share in the growing markets for gasoline and other oils. New refineries were built in the flush oil fields, and these strove for a share even of distant markets. As the years passed, competition was not limited to the sale and marketing of products alone. It extended

Early tank-wagon delivery, following single-barrel deliveries (Standard of Indiana photo)

[1]Virgil B. Guthrie has been a student of the oil industry for nearly half of its first century. He joined the staff of *National Petroleum News* in 1915 and was its managing editor for many years. Prior to his recent retirement he was editor of *Petroleum Processing*.

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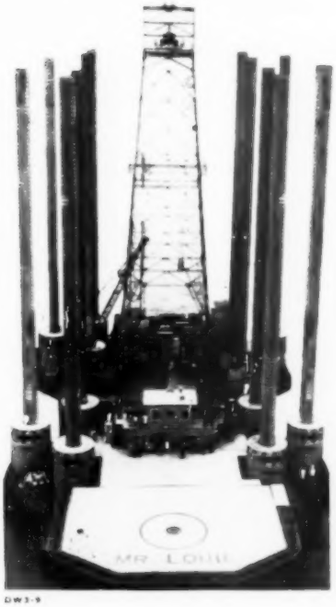

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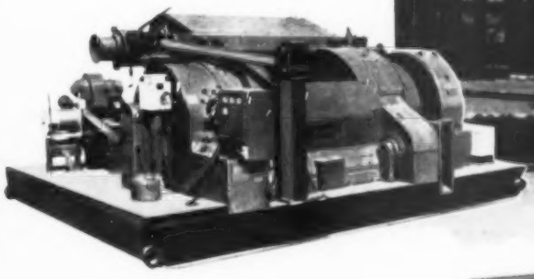

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to the refiners' efforts to make improved products and, in even later years, into the oil-company research laboratories to find new products and markets for them. The petroleum industry thrived under competition.

The joint effect of these various factors was an amazing expansion in the volume of the established products marketed and in the new markets which were found. From 1918, the first year for which reliable statistics are available, the volume of all petroleum marketed in the United States has grown almost ninefold. The consumption of gasoline today is 19 times what it was in 1918. The history of the marketing and use of petroleum in the first 50 years of the industry makes more vivid the developments taking place in the second five decades.

The Early Days: The first marketing of petroleum on record was as a medicine, and before the Drake well. Along about 1847, Samuel M. Kier, of Pittsburgh, started to bottle petroleum which oozed to the surface from his father's salt wells near Tarentum, Pa. He sold it through agents as a "remedy for the ailments of humans and animals." He received a good price for his product, at the recorded rate of $2.25 a gallon. Distribution costs were high, so Kier built a five-barrel still in the early 1850's and recovered an illuminant he called "carbon oil." Other firms, about this time, were distilling "coal oil" from petroleum seepages in Pennsylvania, taking the name from a similar product distilled from coal and used as lamp oil.

The first so-called petroleum refinery, at Oil Creek, Pa., went onstream in 1861. Its chief product, and that of the other early refineries which were built in the Pennsylvania oil fields and in Pittsburgh and Cleveland, was kerosine. Kerosine has proved to be one of the steadiest and sturdiest products the refiners make and market. In demand first as an illuminating oil, it survived the coming of gas and electricity, to become used for space heating. Currently, it is a component of fuels for gas turbine-powered aircraft. In 1918, about 34 million barrels of kerosine were marketed in the United States. Today the demand in this country is around 113 million barrels annually.

The early refiners marketed some naphtha as stove gasoline, but the main problem was its disposal as a byproduct. The lubricating oils marketed were for general application, including steam cylinder oils. Wax was made, chiefly because it had to be removed from lubricating-oil stocks. Axle grease was sold, through the country stores, for the wagons and buggies which traveled the dusty or muddy highways.

These early years of the petroleum industry did bring one development which has had a permanent influence on the marketing or large-volume products. This was the introduction of tank-wagon deliveries. Along in the 1880's, a Middle West oil company started country routes to supply farms and stores with kerosine and other items. This became an established and continuing practice with all oil companies. Today, the industry's pricing structure for gasoline and light heating oils is based on the tank-wagon market, which includes refinery cost and transportation cost, plus the cost of truck or transport delivery from the bulk terminal. This practice of moving products to the consumer, or centers of consumption, by its own transportation means developed to the point that the oil companies own tank cars, transport trucks, barges for inland waterways, and coastwise and ocean tankers. More recently, pipelines have been installed to move gasoline, heating oils, and even liquefied petroleum gas. Product pipeline mileage in the USA is nearly 40,000 miles, of 15 million barrels capacity. Almost from the start, the oil companies built pipelines for crude-oil transportation.

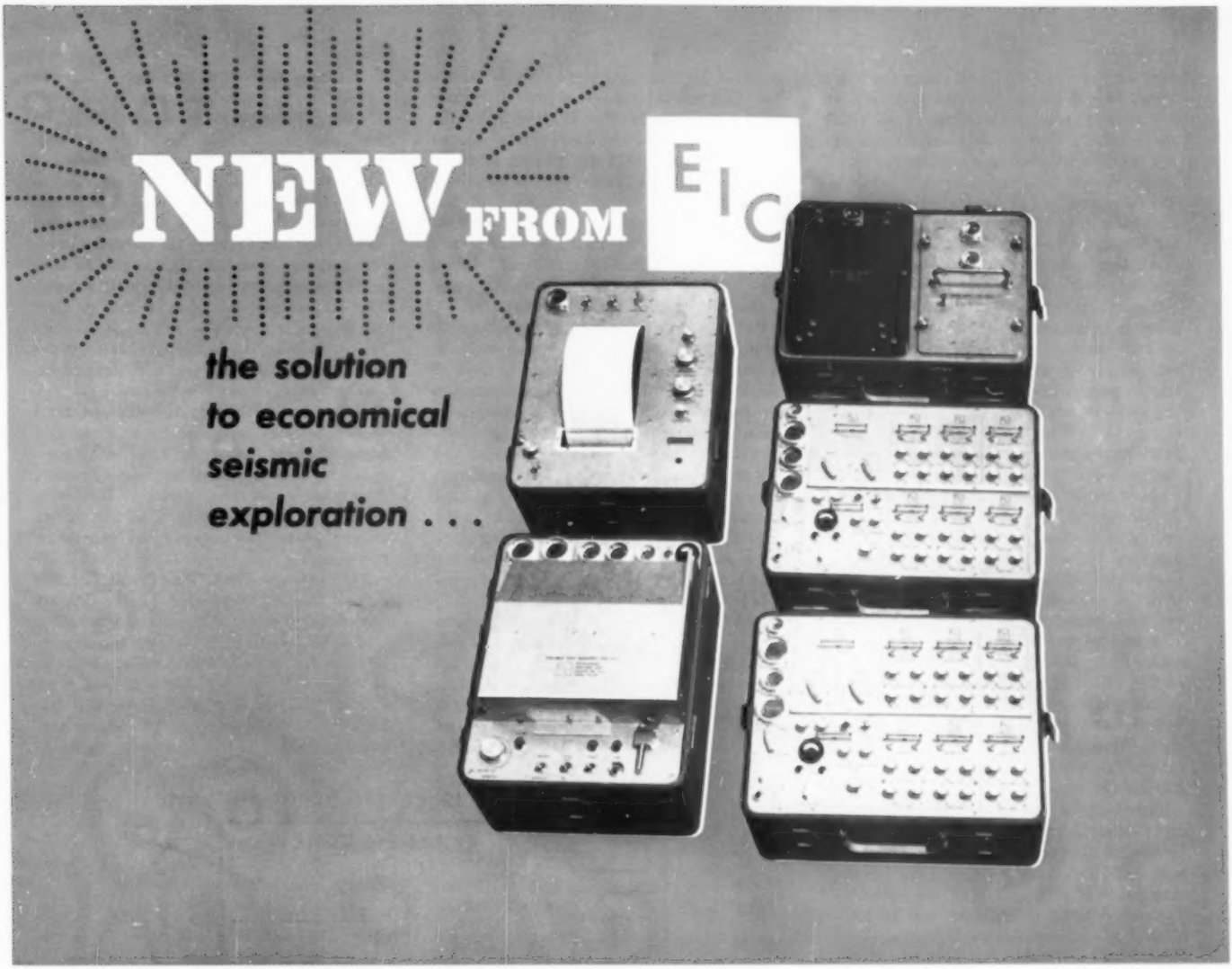
The Gasoline Age: Even before 1900, some persons envisioned the coming of automobiles in large numbers over the country. Among them was William M. Burton, a chemist, who came to work for the Standard Oil Co. (Indiana) after his graduation by Johns Hopkins in 1889. He became interested not only in the possibility of automobiles appearing on the roads, but also in the problem of what they would use for fuel. Some authorities believed kerosine would be used, since it was already widely available. Dr. Burton believed the accepted automobile fuel would be gasoline, and that more abundant supplies would be needed. He convinced officials of his company to the extent they gave him two assistants, and the three went to work in an "experimental house" back of the office building at the Whiting, Ind., refinery. They worked on the principle of applying heat and pressure to transform the petroleum molecule by breaking it up into smaller-size molecules, in compounds suitable for motor fuel.

By 1911, the Burton thermal cracking process had been developed to the point his company decided to build 120 cracking stills. There were then less than 700,000 automobiles in use in the country. Dr. Burton was given a patent on his process in 1913. By straight distillation, only 15% to 18% of gasoline could be recovered from crude oil. Through cracking, at that time over 30% of gasoline could be recovered, and today yields in some refineries are over 50% of the crude processed. If the gasoline required even in World War I had to be made from the straight distillation of crude oil, it would have been necessary to process much larger volumes of crude. Other products would have been made in far larger volumes than were required. During the first world war, between five and six million motor vehicles were registered in the USA. Gasoline demand in 1918 was 74,500,000 bbl, already more than twice the volume of kerosine consumed.

The First Service Stations: While Dr. Burton was working on his process to make more gasoline from crude oil, others in the oil companies were concerning themselves with how fuel would be served to the automobiles when they did arrive in numbers. Their fuel tanks were at first filled at the curb by stores which carried gasoline in tanks on their premises. In 1905, an oil company in St. Louis installed a special tank on its bulk storage property and filled automobile tanks through a garden hose. In 1910, an oil company in Detroit opened what is believed the first drive-in station, with a gasoline pump on an island and with covered driveways. This method of servicing

A 1919 highway: Washington, D.C., to Richmond, Va. (photo courtesy Public Roads Administration).

Isaac Davis of Dayton, Ohio, makes first gasoline sale from a "barrel" tank wagon in 1874 (Standard of Ohio photo).



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cars caught on rapidly, and today there are about 200,000 gasoline service stations over the country, about one-eighth of all retail trade outlets. This development in marketing gasoline followed the principle of tank-wagon deliveries, viz., taking the product to the consumer, or at least striving for the convenience of the consumer in supplying his petroleum needs.

Another milestone in the marketing of gasoline was the introduction in 1923 of tetraethyl lead, a chemical compound put in gasoline to suppress the knock in an engine at high combustion pressures. The knock was annoying to motorists and reduced engine power. Inventor Charles F. Kettering had been working on this problem starting in 1916. With the TEL additive widely available, most oil companies began to sell a higher-octane premium-grade gasoline at their stations, as well as their established regular-grade. This marketing practice of selling more than one grade of motor fuel has been followed since. Today, some companies also sell a super premium gasoline, with Research octane numbers over 100, for the new model, higher compression cars. The general availability of higher octane motor fuels, secured either through the use of the TEL additive or through improved refining processes, gave impetus to the building of more powerful automobile engines through increasing their compression ratios. An accompanying table shows the increase in compression ratios since 1925.

More Volume Products: During the 1920's and 1930's, the volume of gasoline marketed by the oil companies continued to expand, with only a small decline during the depression years of 1932 and 1933. By 1940, the domestic demand for gasoline was 589,490,000 bbl, over five times the 1920 demand of 101,208,000 bbl. During this same period, the consumption of two other petroleum products assumed volume proportions. These were light heating oils and diesel fuel oils, both made from the refiners' distillate fuel-oil production. In 1932, sales of all grades of heating oils, distillate and residual, were 44 million barrels. By 1942, the sales of distillate fuel oils for space heating alone were 121 million barrels. The convenience and cleanliness of oil heating was taking this market away from coal. By 1955, the rate of expansion in sales had dropped due to the competition of natural gas, as the natural-gas transmission lines were extended into the East and Northeast. However, the total volume of distillate fuel oil marketed in 1955 was nearly 340 million barrels.

Of the four grades marketed today, the largest proportion of fuel-oil sales is represented by the No. 2 grade. The growing practice with oil companies is to store and handle only two grades, the light kerosine-type No. 1 and the No. 2 oil. By means of the degree-day system used by most oil companies, deliveries of heating oils to the consumer are made as needed. The householder does not have to bother to check the supply in his tank.

Sales of diesel fuel oil, another distillate product, have also grown greatly in recent decades. In 1934, they were only 12,725,000 bbl. This market jumped to around 70 million during World War II, and today the volume is over 170 million barrels. Almost half of the sales of diesel fuel oil is to the railroads to power their diesel locomotives. The period of greatest expansion in this market was in the 1940's when the dieselization program of the railroads was in full swing. Now the market for diesel fuel oil for buses, trucks, and off-the-highway automotive equipment is growing faster.

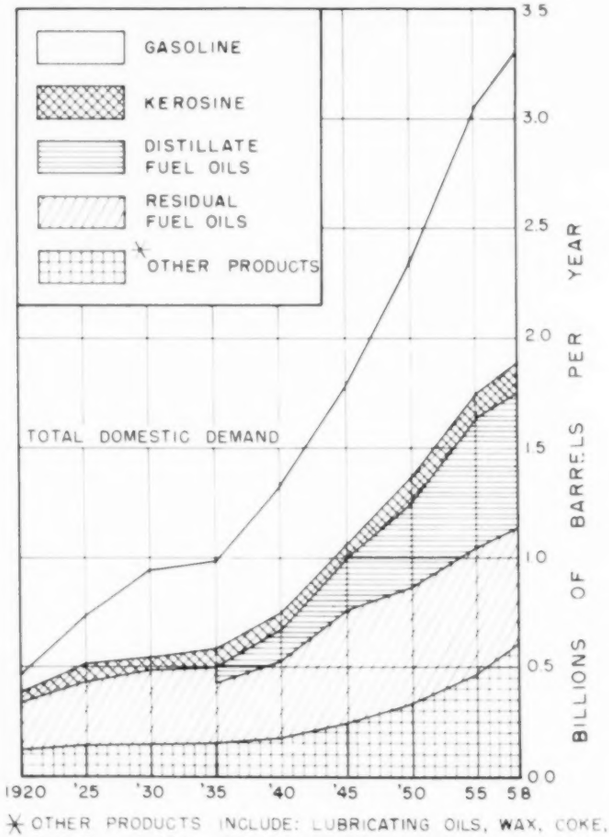
Petroleum asphalt, including road oils, is another product moving into the ranks of volume markets. During the early days of the automobile, petroleum byproduct oils were used to lay the dust on country roads. Then the advantages of asphalt for highway surfacing and paving were learned, and this market expanded rapidly. Demand was 80 million barrels in 1952, and today consumption has reached 110 million, with the joint federal-state highway building program only in its early stages. Asphalt for road building moves from refineries to markets in contractors' equipment.

The Fastest Growing Market: The extracting of liquid products from natural gas, and later from refinery gases, has provided many oil companies with another volume market, liquefied petroleum gas—also known as LPGas, LPG, "bottled gas—and sold under many brand names. This market first passed the 100 million-gallon sales in 1936. Twenty years later, sales were 6,635,736,000 gal (nearly 158 million barrels). The expansion of sales by 60-fold in the two decades makes it the fastest growing market of any petroleum product. Its volume today is larger than that of the refiners' kerosine. The largest single use of LPGas is classified as domestic and commercial, for space heating, cooking, water heating, and similar uses, each representing relatively small volume. The largest present sales of this product are in or near the states with large natural-gas production. The extension of transportation facilities for LPGas will expand its markets in other parts of the country.

Deliveries and sales to domestic and small industrial users are generally on a metered basis. Markets frequently have to be preceded by sales of the stoves, water heaters, and other appliances in which LPGas is used. Thus, the marketing of LPGas differs from that of the conventional petroleum products.

The Aviation Field: World War II catapulted the oil companies in the United States into the manufacture and marketing of aviation gasoline. In 1941, the total use in this country was around 10 million barrels. At the peak of the war effort, in 1944, total demand for avgas at USA refineries was 184,356,000 bbl, most of it 100-octane and over. In producing this enormous supply of

PETROLEUM DEMAND IS EIGHTFOLD THAT OF 1920

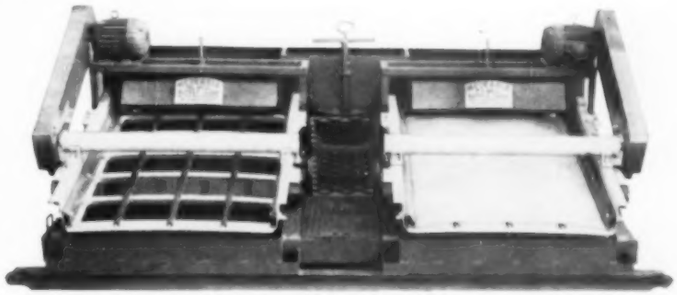


* OTHER PRODUCTS INCLUDE: LUBRICATING OILS, WAX, COKE, ASPHALT, L P GAS, JET FUELS SINCE 1952, AND MISCELLANEOUS.

New MEDEARIS TYPE X MUD SHAKERS

with the flow gate control for even flow

SINGLE SHAKER



DUAL SHAKER

Newly engineered and redesigned, this new Medearis Single Type X Mud Shaker has fewer moving parts than any other mud shaker. The new flow gate control insures even distribution of flow of mud over the whole screen surface. Simplicity of construction and operation reduce maintenance far below what is usually considered normal. (Some operators report savings as great as 50%.) There are no breakable tension boards. The new, simplified rubber strip deck is easy to install and gives longer screen life. All parts are corrosion-protected, and the vibrator housing and screen box are hot-dip galvanized. The vibrator is roller-bearing mounted and housed for complete protection. Tension and vibration are uniform over all parts of the screen.

Weight has been reduced to facilitate mounting and rigdown. The compact design also contributes to easier handling. Depending upon screen mesh opening and pump capacity, the Medearis Single Type X Mud Shaker will handle up to 800 gallons per minute of average drilling mud. Units can be supplied with or without surge box.

The Medearis Dual Type X Mud Shaker consists of two Medearis Single Type X Mud Shakers complete with bottom tank and new flow gate control which insures even distribution of flow of mud over the whole screen surface. These dual shakers are equipped with a surge box in which the flow of mud coming directly from the well is slowed down to ensure an even distribution and flow of mud over each shaker. The dual unit is also equipped with a by-pass for by-passing either or both shakers during mechanical maintenance or in the event the operator is using a lost-circulation material which he does not want to pass over the shakers. A cleanout valve located directly in the bottom of the surge box assures easy cleanout operations.

The dual shakers are mounted on a unitized skid so that the entire assembly can be easily tailboarded and loaded on a truck without the need for disassembling or separating the shakers. Mud handling capacity is equivalent to that of two Medearis Single Type X Mud Shakers.

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Report for 1958

The British Petroleum Company

Production, sales and earnings of the BP Group reached record levels in 1958. However, because expansion in 1957 was arrested by the effects of the Suez crisis, the gains of 1958 should be related to a two year period rather than indicative of a single year's expansion. As a result of lower prices in 1958, net sales of the Group rose only slightly from £ 595,942,000 to £ 598,285,000.

There are several factors militating against an early improvement in trading conditions for 1959. Demand though increasing has not caught up with the supply. Also, more oil is coming on the market from newly developed areas such as the Sahara and from Russian sources. Although 1959 sales are expected to exceed slightly the tonnage attained in 1958, present conditions do not provide grounds for anticipating that 1959 will show an increase in trading margins. The basic long-term consideration is, however, that a continuing expansion of oil consumption is forecast.

Net income of the BP Group in 1958 amounted to £ 63 million. This included all income obtained from crude oil production, refining, transportation and marketing. Nearly twice this amount, namely £ 119 million, was paid under the terms of the fifty-fifty profit sharing arrangement to the oil producing countries in the Middle East which provide the bulk of BP's crude oil production.

An important factor is that the oil companies must find the capital to provide facilities for the production, refining, transportation and delivery to consumers in larger quantities year after year as demand increases. As an illustration of the magnitude of the sums involved in production operations alone, BP and associated companies have underway development projects in the Middle East costing over £ 150 million. The recurring need for heavy capital expenditures means that a high proportion of the companies' earnings must be ploughed back into the business. Over the past decade this proportion has averaged 73 per cent for British Petroleum. The total capital expenditure of the BP Group in all areas of operation in 1958, including the expenditure by non-consolidated subsidiaries and BP's proportion of the expenditure by associated companies in which it has a part interest, amounted to £ 137 million.

THE BRITISH PETROLEUM COMPANY

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THE BRITISH PETROLEUM COMPANY LIMITED
GROUP INCOME STATEMENT
FOR THE YEAR ENDED 31st DECEMBER

	1958	1957
Sales Proceeds	£829,294,000	£792,992,000
Deduct: Sales Taxes, Customs and Excise Duties, etc.	231,009,000	197,050,000
Net Sales	598,285,000	595,942,000
Dividends and Other Income	17,567,000	11,985,000
	615,852,000	607,927,000
Cost of Oil, Operating, Selling and Administration Expenses	423,424,000	434,437,000
Depreciation and Amounts Written Off	48,533,000	43,463,000
Interest Payable	5,952,000	3,363,000
	477,909,000	481,263,000
Income Before Taxation	137,943,000	126,664,000
Taxation	74,758,000	71,480,000
	63,185,000	55,184,000
Income applicable to Minority Shareholders	233,000	550,000
Net Income	£62,952,000	£54,634,000
Attributable to:		
Consolidated Companies	61,923,000	52,018,000
Non-Consolidated Companies	1,029,000	2,616,000
	£62,952,000	£54,634,000

SALES

Group sales of crude oil and refined products reached an all-time high of 1,274,000 barrels per day, a gain of 185,000 barrels over 1957 or 1956. Because expansion in 1957 was adversely affected by the Suez crisis, the large gain in 1958 should be related to a two year rather than a single year's growth.

PRODUCTION

BP's main sources of production were again Iran, Iraq, Kuwait and Qatar — 1,247,000 barrels per day, compared with about 1,000,000 barrels in 1957. The company also had production interests in Trinidad, Nigeria, United Kingdom, Canada, Germany and Sicily totaling some 20,000 barrels daily.

REFINERIES

Throughput from 16 refineries located in Europe, the Middle East and Australia was approximately 780,000 barrels per day, up 120,000 barrels over 1957. New refineries are under construction in Canada and Germany.

TANKERS

The Group's tanker fleet at the end of the year consisted of 157 ships totaling 2,600,000 deadweight tons. An additional 3,000,000 tons were on charter. Currently under construction or on order are 47 tankers, ranging in size from 15,000 to 65,000 tons.

DIVIDENDS

The Board of Directors have recommended a final dividend of one shilling and three pence per £1 ordinary stock unit free of income tax, making a total dividend for 1958 of one shilling and nine pence per ordinary share free of income tax on the present increased capital. The annual general meeting will be held in London on May 21, 1959.

LIMITED

Copies of the Annual Report and Accounts may be obtained from the Purchasing Agent in U. S. A. for BP Trading Ltd., 620 Fifth Avenue, New York 20, N. Y.

PETROLEUM DEMAND IN USA 1918-1958
(Millions of Barrels Per Year)

Year	Gasoline	Kerosine	Distillate Fuel Oil	Jet Fuel	Residual Fuel	Lube Oils	Wax	Coke	Asphalt Road Oil	LPGas, Misc.	Total	Year
1958	1,417.9	113.3	652.5	94.5	531.1	39.4	4.3	31.1	102.1	322.1	3,308.6	1958
1957	1,392.9	107.7	616.1	72.9	548.8	41.2	4.4	27.0	96.1	311.3	3,218.6	1957
1956	1,373.1	117.3	615.8	72.1	562.8	43.9	4.3	24.8	99.4	299.4	3,213.1	1956
1955	1,334.2	116.8	581.1	56.3	557.0	42.5	4.1	24.4	92.6	278.7	3,087.7	1955
1950	994.3	117.8	394.8		553.8	38.8	3.2	15.0	65.6	191.6	2,375.0	1950
1945	696.3	75.6	226.1		523.4	35.3	2.4	9.2	40.8	163.5	1,772.7	1945
1940	589.5	68.8	160.8		340.2	24.7	1.3	7.0	36.0	98.3	1,326.7	1940
1935	434.8	47.6	86.0*		280.7	19.7	0.9	6.7	21.6	85.6	983.7	1935
1930	394.8	34.7			368.5	21.6				106.8	926.4	1930
1925	223.9	39.9			307.0	20.6				135.7	726.9	1925
1920	101.2	33.1			185.9	14.7				120.8	455.8	1920
1918	74.5	34.4			142.7	13.8				93.9	359.4	1918

*Included with residual fuel oils prior to 1932.

AVERAGE HORSEPOWER AND COMPRESSION RATIOS OF AMERICAN CARS, 1925-1959*

Year	Maximum BHP	Compression Ratio
1925	59.046	4.40
1930	90.97	5.15
1935	109.70	5.99
1940	109.720	6.43
1946	104.50	6.68
1947	107.80	6.68
1950	110.90	7.03
1951	116.2	7.07
1952	122.1	7.18
1953	133.0	7.44
1954	150.8	7.64
1955	173.1	7.96
1956	206.8	8.55
1957	236.7	8.96
1958	258.6	9.47
1959	260.0	9.50

*Ethyl Corp. data.

PRODUCTS MADE BY THE USA PETROLEUM INDUSTRY*

Class of Product		Number of Products
Fuel Gas		1
Liquefied Gases		13
Gasolines		40
Motor	19	
Aviation	9	
Other (Marine, Tractors, etc.)	12	
Gas Turbine (Jet) Fuels		5
Kerosines		10
Distillates (Diesel Fuels and Light Heating Oils		27
Lubricating Oils (Light and Heavy, Compounded and Uncompounded)		1,156
White Oils:		100
US Pharmacopoeia	78	
Technical	22	
Rust Preventives		65
Transformer and Cable Oils		12
Greases		271
Waxes (Crystalline and Microcrystalline)		113
Residual Fuels Oils		16
Asphalts (Including Road Oils, Tars, etc.)		209
Cokes		4
Carbon Blacks		5
Chemicals, Solvents, Misc.		300
Total		2,347

*From *Information Bulletin No. 11*, the American Petroleum Institute.

aviation gasoline, refiners had to call on petroleum hydrocarbon materials which were also needed to manufacture synthetic rubber. Production of synthetic rubber, most of it from petroleum materials, expanded from almost nothing to 1.8 billion pounds in 1945. Without the new refining processes, embodying the transforming of the molecular structure of hydrocarbon compounds, refiners could not have supplied the wartime demand for materials for aviation gasoline and synthetic rubber.

After the war, the requirements for aviation gasoline dropped sharply for a few years, then started to increase as commercial aviation expanded. The demand in 1955 was 70 million barrels, of which military requirements were 43,400,000 bbl. Just as they built service stations to meet the convenience of motorists in getting their automobile fuel supplies, the oil companies have installed storage and dispensing facilities at the airports for servicing the planes of commercial air lines and private planes. Engineering problems have been encountered here in insuring that the gasoline is kept free from even minute quantities of water and contaminants until the fuel is placed in the aircraft tanks.

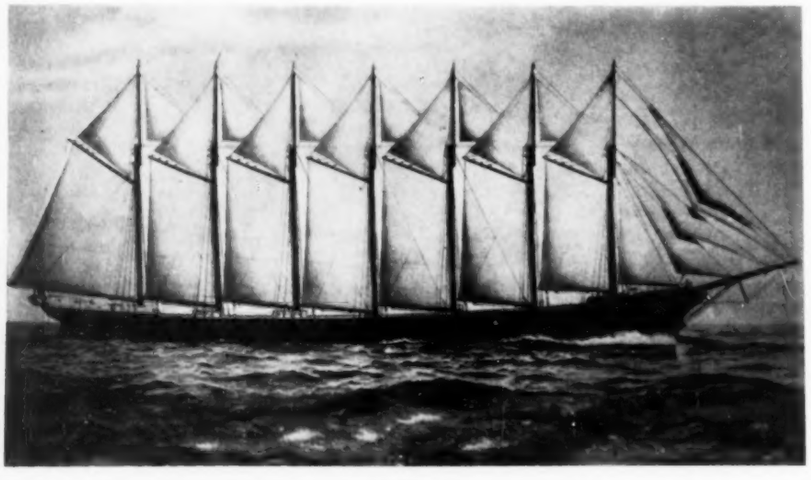
Also in the aviation field, the so-called jet fuels, for gas turbine-powered aircraft, are moving toward a volume market, which was hardly recognized 10 years ago. Requirements for this fuel at USA refineries have expanded to around 95 million barrels, mainly for military aircraft. Commercial requirements are expected to increase as the commercial air lines use more gas turbine-powered aircraft, in place of planes with reciprocating engines. In view of the wide range of flights of this type of aircraft, the fuel marketing problem for the oil companies is to make sure that the same grade of fuel is available wherever the plane is serviced, even outside the USA.

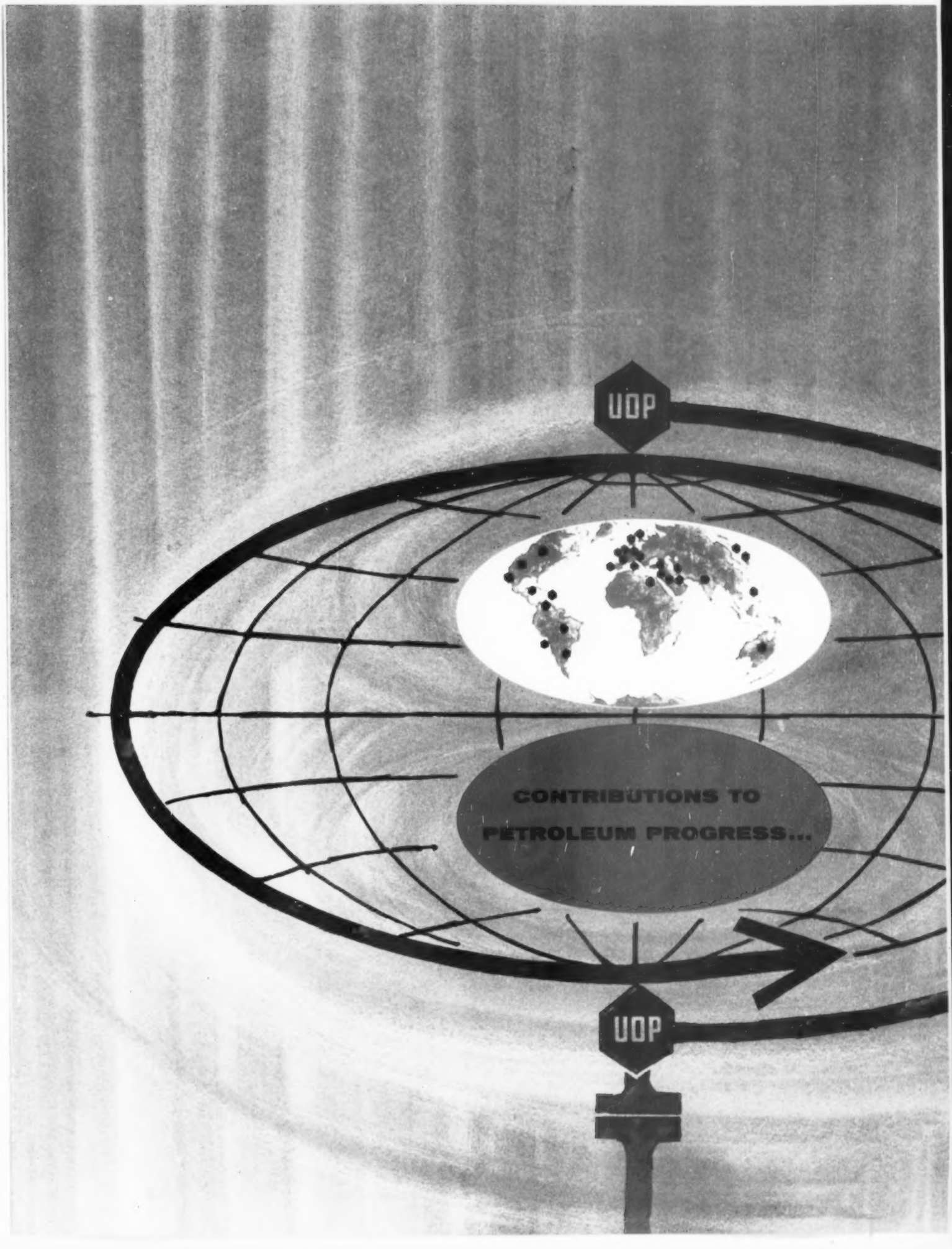
Petrochemicals: Many oil companies are now engaging in the manufacture and marketing of chemical products made from petroleum and natural gas, and the intermediate materials from which petrochemicals are manufactured. In this business, volume is figured in pounds, in place of the gallons and barrels in which the conventional petroleum products are measured, and the marketing procedures and sales outlets are entirely different. Sales of one billion pounds a year create a volume petrochemical market. Output of all petrochemicals in 1957 is estimated at 38.3 billion pounds every day. In value, total petrochemical production in 1955 was $3.7 billion, 55% of the value of the USA output of all chemicals. There are now 370 petroleum, natural-gas, and chemical plants in this country engaged in the manufacture of petrochemicals. Their entire raw-material requirements are only about 2% of our total production of crude oil and natural gas. The abundance of supplies of raw materials is expected to insure future expansion.

The great expansion in the number of consumer products made from petroleum was disclosed in a recent survey conducted among the oil companies by the American Petroleum Institute a few years ago. The census showed a total of 2,347 individual products ranging from fuel gas to chemicals. A product was listed separately when made by a different formula from other products in the same classification. The accompanying table shows the number of separate products in 22 groups.

Large as is this listing of the pertoleum products marketed today, it is by no means complete. New Petrochemical items are being put on the market every year. In an even newer field, some oil companies are already deep in research to find the liquid and solid fuels from petroleum and allied materials which will be used to fuel the rocket missiles and moon satellites in man's coming conquest of space. The concept that petroleum is nature's storehouse for hydrocarbon molecules which can be fashioned by men into needed materials promises products which are as yet unknown. END

Converted about 1905 to an oil carrier by Sun Oil Co. was the "Thomas W. Lawson," world's largest schooner-rigged sailing vessel.

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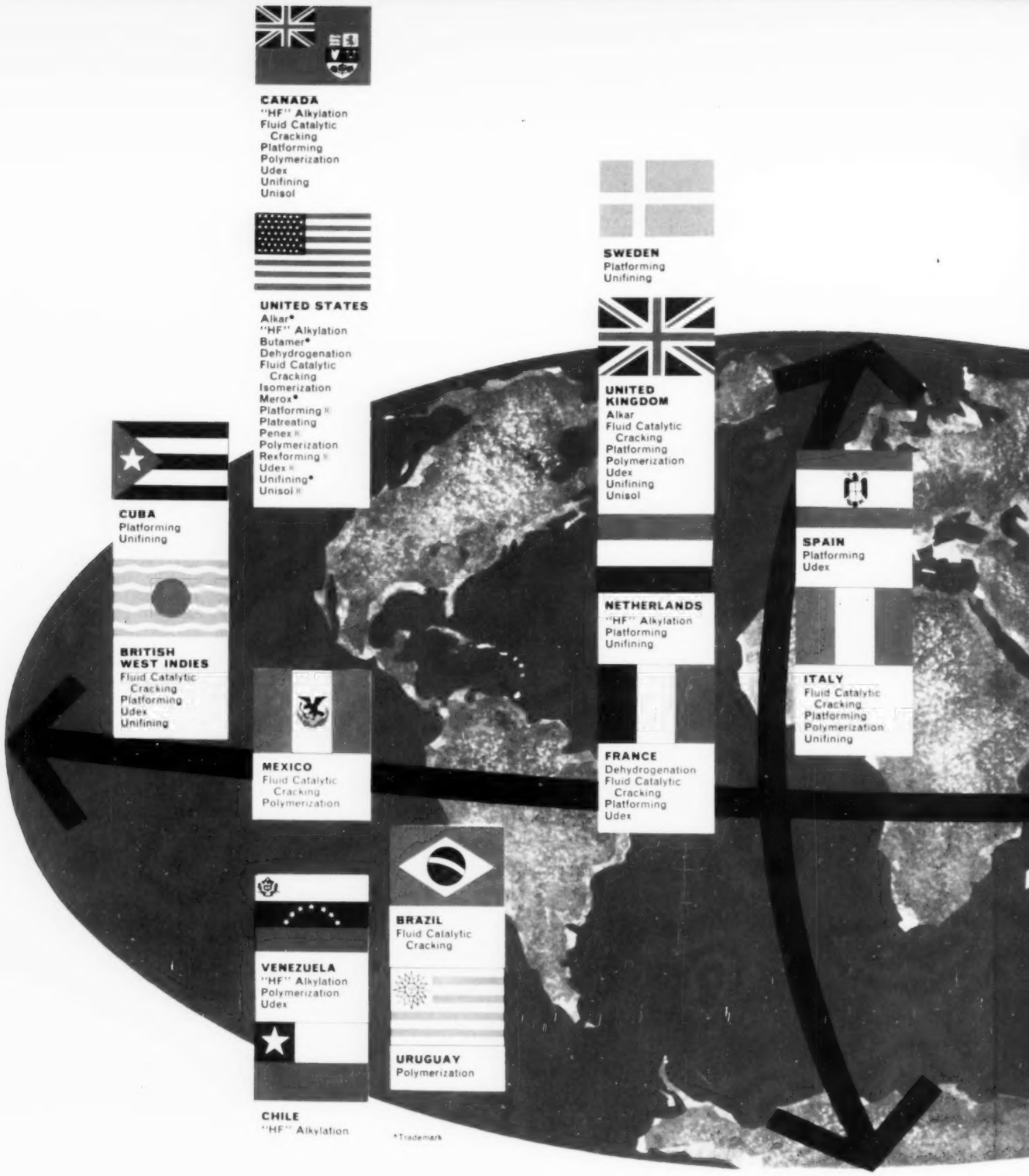
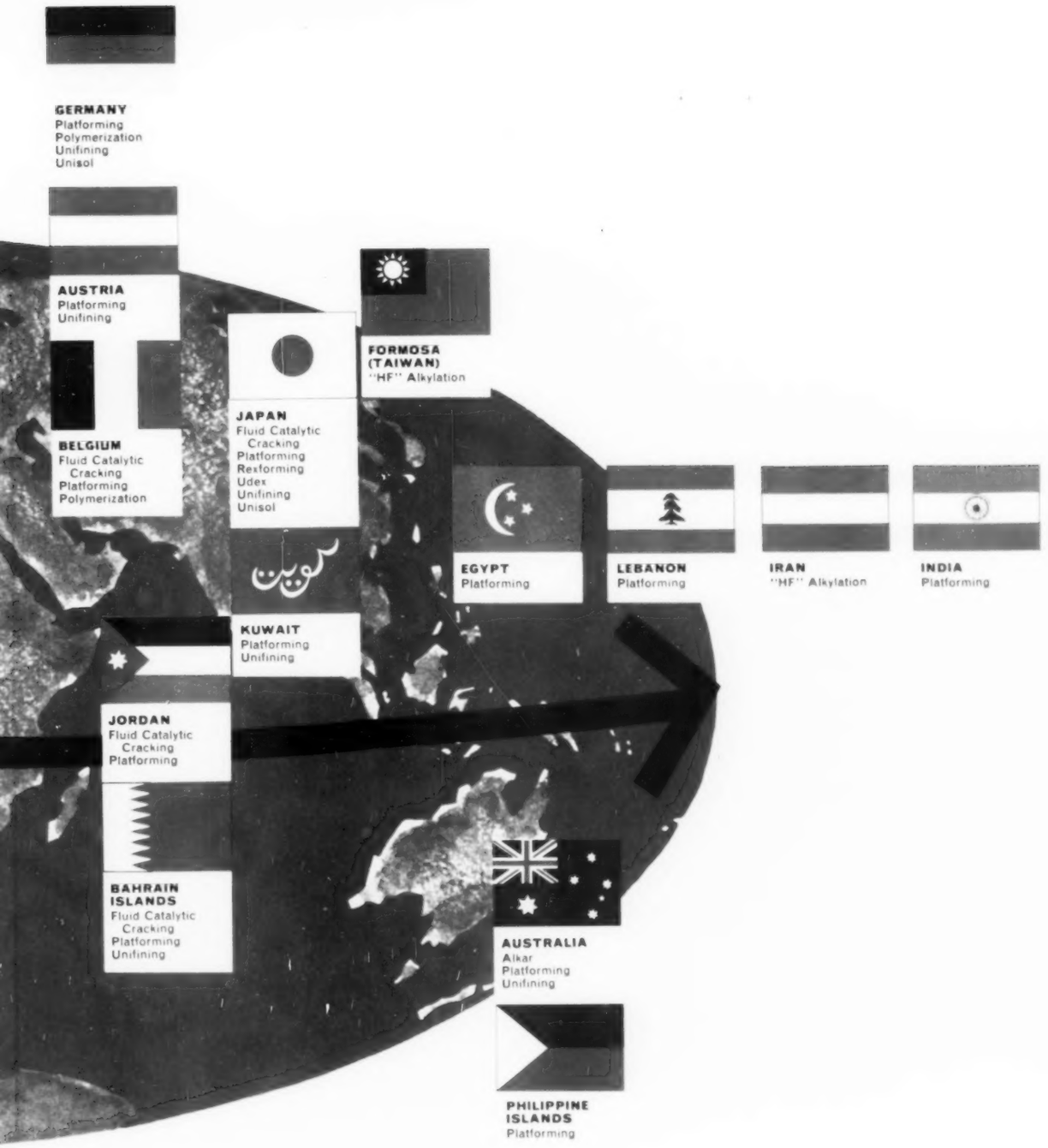


Nearly one half-century ago, Universal Oil Products Company offered to the world a new and better way to refine crude oil. From that day to this the people of Universal have exerted unceasing effort to that end . . . to find new and better ways to process petroleum. The result of this endeavor is evident. Today, through the use of UOP processes and the help of UOP



technology, petroleum refiners in twenty-nine countries throughout the Free World are making more and better products from petroleum . . . meeting increasing demands for higher-quality fuels and petrochemicals. In the future as in the past, UOP will continue to make important contributions to technological progress in petroleum.

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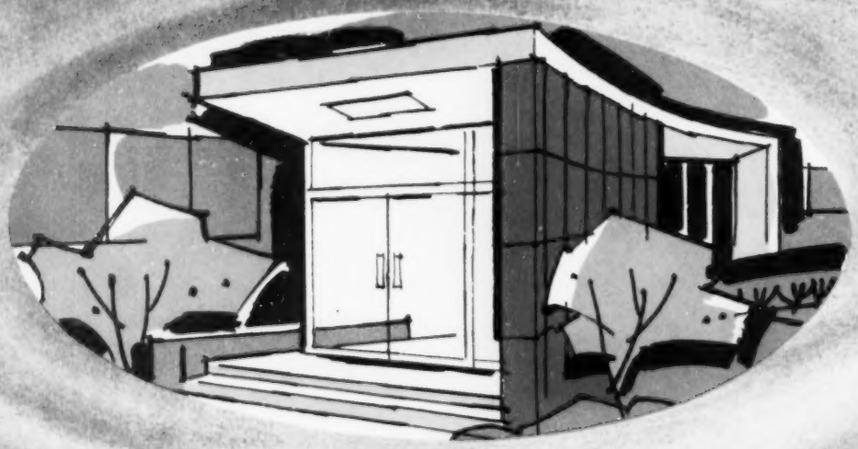

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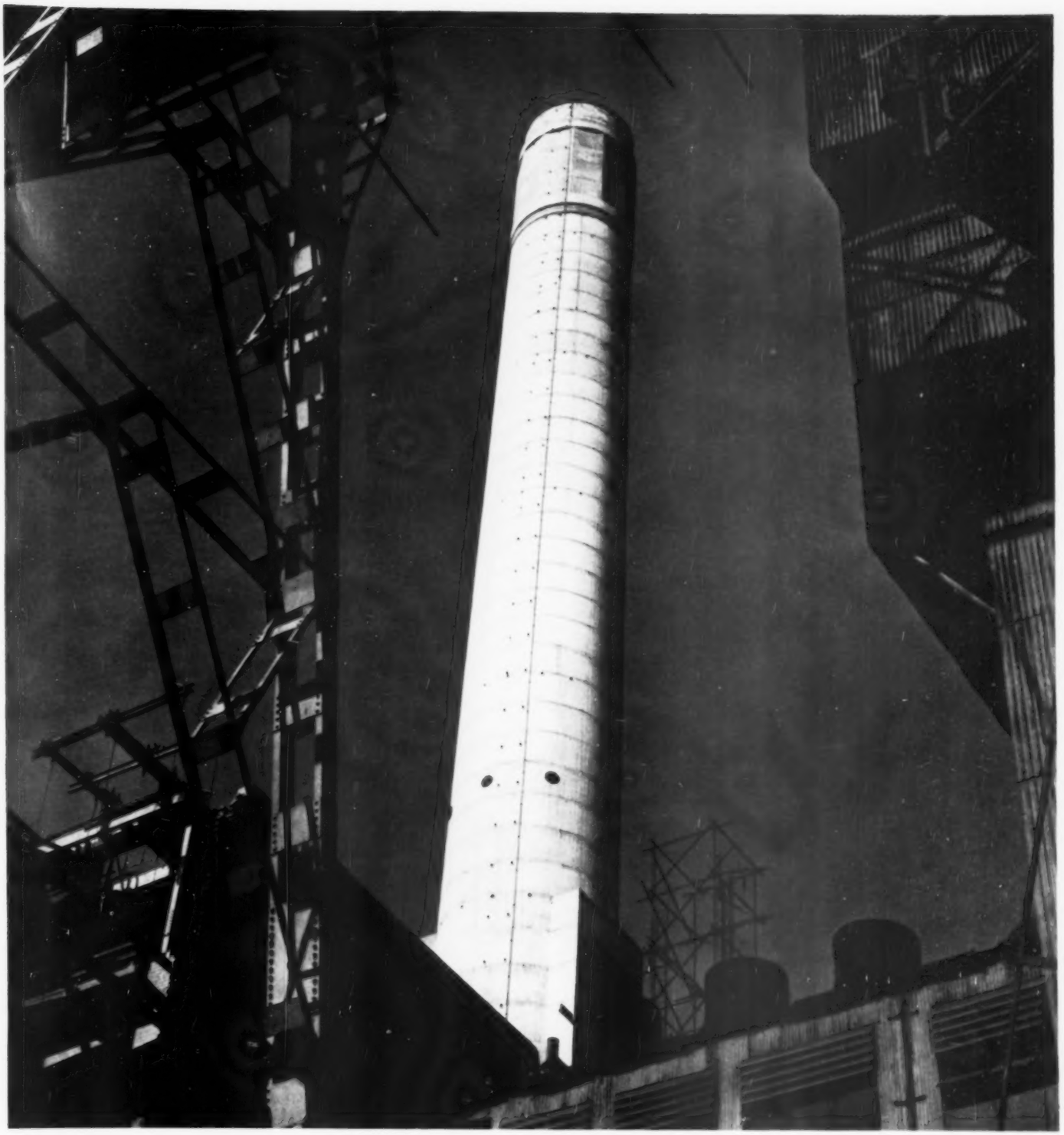

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ROYAL DUTCH/SHELL SINCE 1955

CONTINUED progress has been made by the Royal Dutch/Shell group of companies since the Fourth World Petroleum Congress. The closing of the Suez Canal and the cutting of the pipelines from Iraq in the autumn and winter of 1956/57, which resulted in a very considerable reduction in the volume of oil supplies from the Middle East, particularly to western Europe, posed a major problem which was, however, successfully overcome.

Shell alone were supplying about three million tons of oil to Europe in the summer of 1956, about two million tons of which was coming from the Middle East, three-quarters of it via the Suez Canal and the remainder via pipelines from the Mediterranean coast. Extensive emergency measures were immediately taken by Shell and other international oil companies towards relieving the European oil shortage.

These were subsequently given the support of the governments of western Europe and the United States through the establishment of machinery for joint industry and government consultation. The coordinating machinery thus created, though not concerned with political factors dominating the situation, went a long way toward insuring that, through the most efficient use by the industry of the limited tanker tonnage at its disposal to carry oil from every available source, the deficiency of Europe's supplies was minimized.

When in the early days the position had been carefully investigated and assessed, the committee in collaboration expected that the best program it could achieve was to supply the western European countries with 75% of their normal domestic requirements for the first quarter of 1957. It was a matter of great satisfaction that eventually, through even better performance than had been expected, the countries in question received during the period 85% instead of 75% of their normal consumption. Shell played an active part in all this collaboration.

As a reflection of the Suez period, Shell's Venezuelan production averaged 947,000 b/d in 1957 compared with 773,000 in 1956. Resumption of full use of the Suez Canal and the Syria pipelines in 1958 removed the obstacles to the continued growth of Middle East production, which attained new high levels.

The Iraq Petroleum Co. Ltd and its associated companies, in which Shell has a 23.75% interest, succeeded in completely restoring the rate of flow of crude oil from northern Iraq to Banias and Tripoli, on the Mediterranean coast. With further increases in southern Iraq and in the Qatar peninsula, the combined rate of production towards the end of the year rose to a level of nearly a million barrels a day.

Exploration and Production: An extensive exploration program has continued to be carried out by Shell in various parts of the world during the period under review. In the United States, Shell Oil Co.'s exploration and development work increased substantially the estimated reserves of crude and gas. These, in the main, came from southern California, the "Four Corners" area, Louisiana both onshore and offshore, the Anadarko basin in northwestern Oklahoma (mainly gas), West Texas, and Mississippi. The 600-mile 16-in. crude pipeline, in which Shell Oil Co. has a 25% interest, was completed in 1958 from the Four Corners area to Los Angeles, permitting regular production from this area.

Production by Shell Oil Co. of Canada in western Canada grew from just over 6,000 b/d in 1955 to just over 14,000 b/d in 1958. This increase has been greatly facilitated by the completion of pipeline outlets from oil fields in southeastern Saskatchewan. An important gas and condensate discovery was made in 1957 in the Waterton area of southwest Alberta: further investigation has revealed the existence of a major natural-gas field. Other significant gas discoveries were made in the Berland River and Panther River areas, whilst a promising discovery of oil was made at Simonettee River, all in Alberta.

Development activities in Venezuela, Shell's largest source of production, continued at a high level. In 1956 the government awarded new concessions for the first time since 1945, and Compania Shell de Venezuela acquired nearly 60,000 acres of exploitation concessions in Lake of Maracaibo: Production began in one of these two blocks of concessions in 1958, and testing of the first wells in the second block indicated the presence of important oil reserves. By 1958, nearly 250 wells had been completed in Lake Maracaibo by the company.

Construction was begun in 1957 of a new oil terminal, Puerto Miranda, capable eventually of accommodating 65,000-ton tankers, on the eastern shore of the lake. It is coming into operation in stages, and will be completed during the second half of 1960. More than 100 miles of pipelines will feed the terminal from oil-field despatch points.

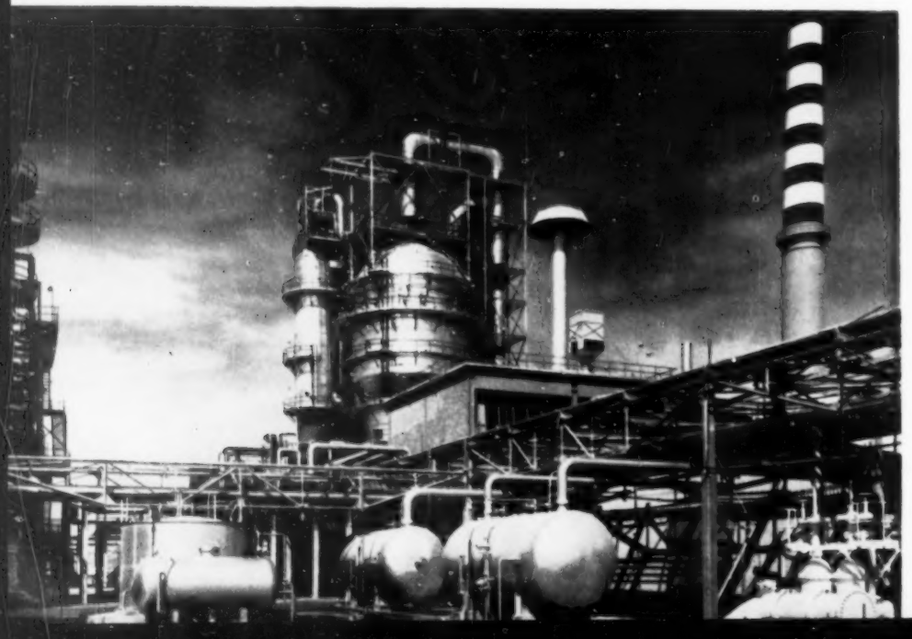
In Colombia, appraisal drilling has continued with encouraging results in the Yarigui oil field, north of Casabe. Production from this field, which lies almost wholly beneath the Magdalena River, is mostly from deviated wells drilled on island sites, reinforced by methods similar to those used by the Dutch to keep the sea in The Netherlands.

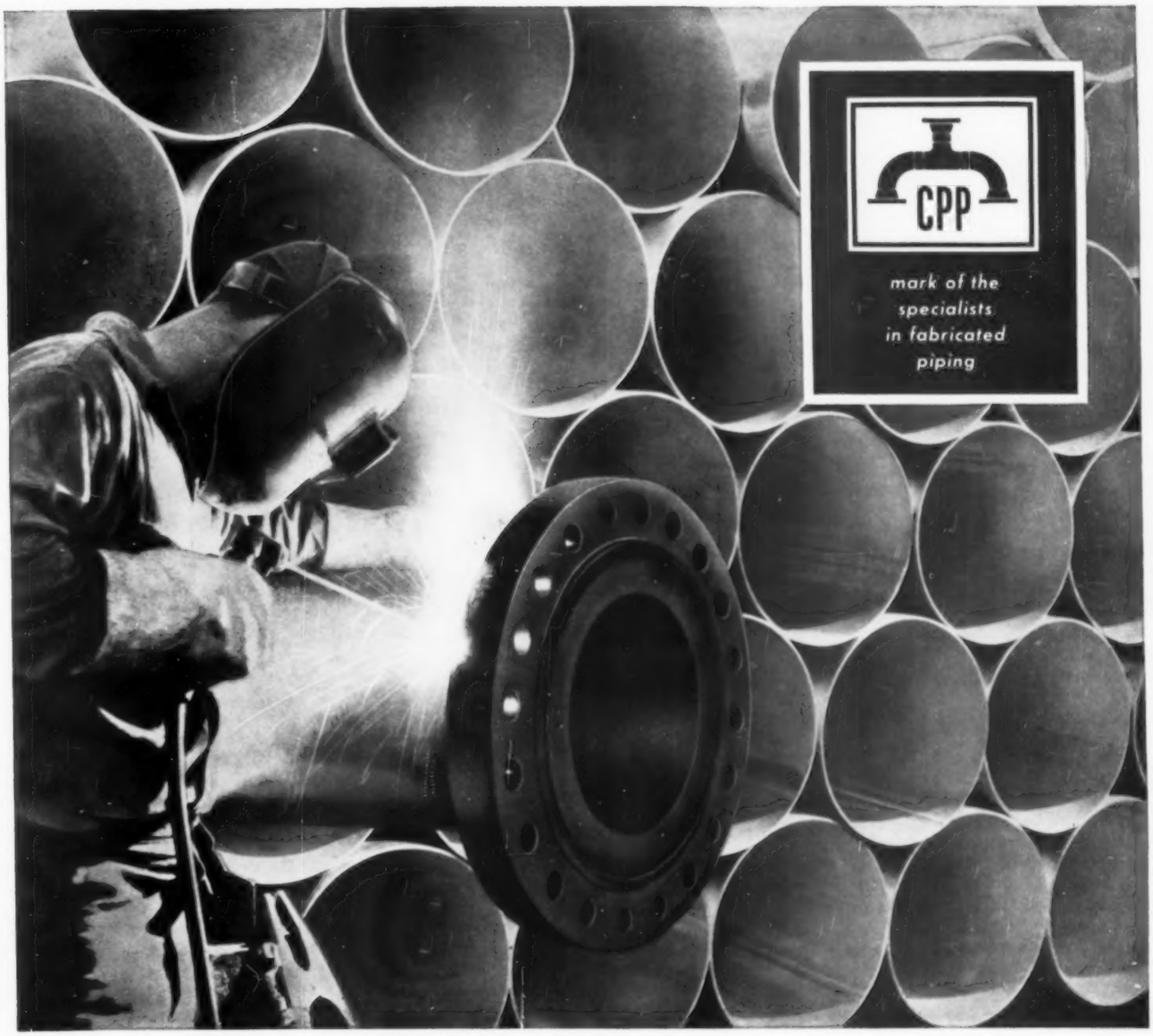
In Bolivia, exploration concessions were granted in 1957 covering large areas east of the Andes. In the same year, Shell acquired a 50% interest in prospecting licenses covering holdings in the northern part of British Honduras, where several exploration walls were drilled in 1958 and only minor oil indications found.

At the end of 1958 a contract was signed for the exploration of an area near the mouth of the Rio Negro, in Argentina.

In the Middle East, activities in Iran, where a Shell company has a considerable interest in the consortium, were energetically pursued. Crude-oil production has

Stripper and generator at 130 million 33,000 b/d cracking and 1,400 b/d alkylation facilities at Shell's Cardon refinery, first of their kind in Venezuela.





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substantially increased over the period. Drilling is to be resumed off Qatar, in the Persian Gulf, where a storm destroyed a drilling platform in January 1957.

A geological and geophysical reconnaissance is in progress in Turkey, and test wells have been drilled.

Exploration has continued in the French Sahara. In 1958, gas and condensate were encountered in a well in the Hamra area, and new oil-bearing structures were found near the Lybian border. In the newly discovered Zarzaitine field, considerable oil extensions were revealed by appraisal drilling.

In West Africa, the first well was drilled in the Niger delta area in 1955. The following year, oil and gas were discovered in two structures—one in the Niger delta and the other in the coastal area to the east of it.

This was the climax of hazardous and costly exploration extending over more than 20 years, in which no less than £27 million had been spent. Much of the work had been carried out in some of the world's worst terrain from an oil man's point of view: in mud and swamps only four or five degrees north of the equator.

The Oloibiri and Afam fields were brought into production early in 1958, when pipelines from these fields to the temporary oil terminal at Port Harcourt were completed. Production had reached a level of 6,400 b/d by the end of the year, and expenditure had risen to more than £40 million.

In Europe, total production in The Netherlands increased to 30,924 b/d in 1958 from 19,554 b/d in 1955, whilst the BPM share in this production rose to 16,000 b/d from 10,000 b/d during the same period. Oil and gas were found in the province of South Holland, and a deep test in the Schoonebeck field found gas in commercial quantities.

In France, exploration was carried out in the southwestern part of the country, but was stopped at the beginning of 1958 after disappointing results. Geological and geophysical reconnaissance in the Paris basin started in 1957, and the first exploration well is presently being drilled.

In the Far East, several marine exploration wells have been drilled in British Borneo offshore from Seria. The government has granted a concession covering the continental shelf and territorial waters off the west coast of North Borneo. A mobile oil drilling platform was completed early this year by a British firm at a cost of nearly £1 million for use off the west coast of British Borneo.

A new company, Pakistan Shell Oil Co. Ltd. in which Shell has a 75% interest, was granted concession areas in 1956 inland in West Pakistan and, mainly marine, in East Pakistan. In West Pakistan, test wells are being drilled.

Exploration is being undertaken in the North Island of New Zealand in conjunction with a British oil company and a New Zealand company; drilling off the first exploration well began in January 1959.

Manufacturing: Eighty-three per cent of Shell's refining is now done in North America, the Caribbean, and Europe, with the remainder in the Middle and Far East, and Shell is now processing about two million barrels daily.

The continued demand for products of still higher quality has led to the introduction of a number of new refinery units to enable Shell to meet these requirements. Emphasis has been particularly on the construction of catalytic reforming and hydrodesulfurizing units to meet the need for top-quality gasoline and gas oils. Three completely new refineries in which Shell has an interest have been built during the period under review—at Anacortes (Washington, USA) in 1955 (55,000 b/d), at Havana, Cuba, in 1957 (28,500 b/d), and at Yokkaichi, Japan, in 1958 (40,000 b/d).

In the United States, an alkylation plant has been added at Anacortes refinery; and catalytic reformers at Wood River (Illinois) and Houston (Texas). Combined catalytic reforming and hydrodesulfurizing units are being built at Wilmington-Dominguez refinery (California) and at Norco (Louisiana).

In Canada, an alkylation unit came into use at Montreal refinery in 1958. Its purpose is the manufacture of high-grade aviation and motor-gasoline components, and of base material for synthetic detergents.

At Cardon refinery, Venezuela, catalytic cracking and aviation-gasoline plants were brought into operation in 1957, and a new crude-oil distilling unit with a capacity of 80,000 b/d began operating in the middle of 1958.

The catalytic cracking unit at Curacao refinery, in the Netherlands Antilles, was put into service in 1957.

In Argentina, the crude throughput at Buenos Aires refinery has been increased by modifications to existing installations.

In Europe, considerabled developments have taken place at Pernis refinery, in The Netherlands. A second catalytic cracking unit came into use in 1956, and an alkylation unit has been built for producing aviation-gasoline components. A catalytic reforming unit for high-quality motor gasolines and two hydrodesulfurizing units for gas oils were completed in 1958.

One of the most significant developments during 1958 was the start of construction of the first major crude-oil pipeline in Europe to supply refineries at inland sites. This new 24-in. line in which Shell has an interest will run from Rotterdam to the Ruhr-Rhineland area of western Germany, and have an initial capacity of 130,000 b/d.

One of the refineries it will supply is a new one now being built by Shell at Godorf, near Cologne. Expected to come into operation in the middle of next year, this refinery will have an ultimate capacity of 80,000 b/d.

A catalytic desulfurizing unit came into operation at the Harburg refinery in 1957. An extension to this refinery at Hohe Schaar, completed in 1958, represents an increase of about 40,000 b/d in Shell's refining capacity in Germany. The extension's new plants include a crude distilling unit, hydrodesulfurizing plants for gasoline fractions and middle distillates, a catalytic cracking plant, and a catalytic reforming unit.

In the United Kingdom, the processing capacity of the Stanlow and Shell Haven refineries have been further increased by modifications to existing installations. At Stanlow, a hydrodesulfurization unit and a new glycol extraction unit have been provided. The catalytic cracking unit has been equipped with apparatus for the generation of steam power by utilizing waste heat. Shell Haven's distilling capacity has been doubled, to 160,000 b/d, by the addition of a second crude distillation unit recently completed; a catalytic reforming unit has also been brought into use.

Under construction at Whitegate, near Cork, in the Republic of Ireland, is a new refinery in which Shell has an interest. Soon to be completed, it will have a capacity of 40,000 b/d.

In France, a catalytic cracking unit was installed at the Petit-Couronne refinery in 1956. The capacity and flexibility of the refinery have been increased with the construction of a crude-oil distilling unit, a vacuum distilling unit for the manufacture of lubricating oil, and a catalytic reforming and desulfurizing unit. At Berre L'Etang, a new installation for the purification of refinery gases will supply town gas to Marseilles.

In Italy, a new catalytic reforming unit was taken into use as part of the modernization program at La Spezia refinery.

In India, a catalytic reforming unit and an Edeleanu plant were installed at Bombay refinery.

In Australia, at Geelong (Melbourne), a catalytic cracking unit and a catalytic reforming unit were taken into use. The capacity of the Clyde (Sydney) refinery has been increased by modification to the distilling unit, and a catalytic reforming unit has been completed.

The main processing units in the new Yokkaichi refinery (Japan) comprise a crude-oil distillation unit with a capacity of 40,000 b/d, and a catalytic cracking plant.

Transportation: One in every five tankers at sea today is carrying oil for the Shell group of companies, and the tanker fleet (owned or chartered by Shell companies) covers about 45 million miles a year on its worldwide voyages.

The total fleet at the end of 1958 consisted of 533 vessels of 2,000 dwt or over, aggregating more than nine million tons deadweight. Of the total tonnage at Shell's disposal, 3.4 million tons were Shell-managed and the remainder chartered.

Financial arrangements made in The Netherlands and the United Kingdom in 1956 made available £56 million for the construction of new tankers to be chartered to Shell companies for very long periods. Arrangements were also made for chartering, on a demise basis, a number of ships to be built in the United States.

Tonnage on order at the end of 1958, either for ownership or to be made avail-

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able under these long-term financial arrangements which insure the use of the vessels for the whole of their working lives, consisted of 49 vessels totaling 1.7 million tons. Of this, nearly 200,000 tons was launched in 1958, and the remainder will leave the slipways during the next four years. The larger vessels range from 47,000 to 65,000-73,000 tons.

Shell owns, either wholly or partly, more than 19,200 miles of pipelines in various parts of the world to move crude oil, products, and natural gas. Of this total, 12,800 miles are situated in North America.

Marketing: Shell's sales of oil products and crude throughout the world have been running at more than 2¼ million barrels a day, divided half-and-half between the Western and Eastern Hemisphere. In the Eastern Hemisphere, where demand is rising appreciably faster than in the Western Hemisphere, Shell holds a larger share than any other company.

The growing requirements of oil in western Europe for power, largely for use in industry and shipping, has resulted in an increasing demand for the heavier products. Shell, however, played a conspicuous part in supplying motor gasoline with ever higher standards of performance to the market of both hemispheres.

The development of the motor-car engine has constantly been matched by the evolution of still more advanced fuels and lubricants. Shell introduced 100-octane motor spirit, a fuel which opens the door to engines of still higher compression ratios, and helps motor manufacturers to build in additional power with economy.

In the town-gas industry, the higher prices and shortage of suitable gas-making coals resulted in interest being shown in the purchase of refinery and liquid petroleum gas and liquid petroleum fractions for conversion to town gas. Shell companies played a prominent part in developing this business.

Research and new products: The oil industry early became aware of the necessity for research, and Shell now spends about £16 million a year and employs more than 5,000 men and women in research centers in the United States, the United Kingdom, and The Netherlands. Part of the research is reflected in new or improved products to meet the specialized needs of industry or agriculture.

For example, with the rapid growth of nuclear power and industries associated with it, many new problems of lubrication have arisen. Work in this field has led to the introduction of the Shell atomic power lubricants, a range of radiation-resistant lubricants for use in nuclear power stations and other establishments handling radioactive materials.

From the initiation of the Calder Hall power station project in the United Kingdom, Shell recognized that lubricants would be required for use in situations subject to nuclear radiation. Nothing was then known of the effects of radiation on lubricants, and in 1953 a research program was put in hand at Shell's Thornton Research Center, in Cheshire, in collaboration with the United Kingdom Atomic Energy Authority's Research Establishment at Harwell.

Parallel work was done by Shell Development Co. and Shell Oil Co. in the United States to develop radiation-resistant lubricants, with particular reference to the requirements of the American nuclear-power industry.

In May 1957, Shell introduced on the UK market the first commercially available range of radiation-resistant lubricants for nuclear-power plant under the brand "Shell" APL (atomic power lubricants) which include oils, greases, and hydraulic fluids. 'Shell' atomic power lubricants will be used exclusively in the United Kingdom's first commercial atomic power station which will begin operating next year at Bradwell (Essex). These lubricants are being tested by plant and equipment manufacturers for projected nuclear-power stations elsewhere in Europe.

Meanwhile, research and development work is continuing both in the UK and in the USA, so that new products will be ready as the need arises.

Shell's contribution to the peaceful application of nuclear power has not been confined to the production of special lubricants. In 1947, Shell scientists conceived basic ideas for solving the problem of finding a pure carbon material suitable for the manufacture of graphite forms for use as moderators in atomic reactors. These ideas were quickly established as extremely promising and, by technical and technological experiments carried out cooperatively in the research laboratories of the British government and of Shell, it was found that petroleum coke could be manufactured of such extreme purity that moderator graphite for nuclear reactors could be produced without complicated purification.

The coke so obtained was adopted by the United Kingdom Atomic Energy Authority as the required basic material for the manufacture of high-purity graphite for use in its nuclear reactors, and the availability of such graphite enabled the authority to design and construct the reactors of the first atomic-powered electric generating station at Calder Hall.

Following the decision of the authority in 1955 to adopt this material for use on a large scale, Shell, early in 1958, brought additional plant into operation at Pernis (Holland) for the production of high-purity coke in calcined form to meet the needs of the authority and other potential users.

These achievements illustrate the important part played by Shell in helping to develop a new source of energy which will eventually prove complementary to oil and other sources of power in meeting the energy needs of the world.

The steadily increasing demand of all types of internal-combustion engines has had to be matched by improved fuels and lubricants. The range extends from the huge marine diesel engine of 10,000 or more horsepower to the midget engine of the power-assisted bicycle. At one end of the scale an emulsion lubricant has been developed to reduce wear in marine engines; at the other, a special oil has been made available for the scooter-type engine.

The use of a radioactive piston ring in lubricating-oil research, in conjunction with special equipment, has made possible for the first time the recording of engine wear while the car is actually running on the road—starting, accelerating, cruising, climbing on good roads and bad—conditions which cannot be exactly reproduced in a laboratory.

To meet the needs of the new generation of jet-powered civil airliners flying at high altitudes, Shell was first in the field with a kerosine fuel with a freezing point of —50 C. Both the pure jet and the turbojet engine are extremely sensitive to the minutest traces of water or impurity in the fuel, and here again Shell has introduced new devices to insure maximum safety.

For the aircraft piston engine, a new oil has been evolved containing a special type of dispersant additive. It keeps the engine clean, reduces oil consumption, and enables it to run for longer periods between overhauls.

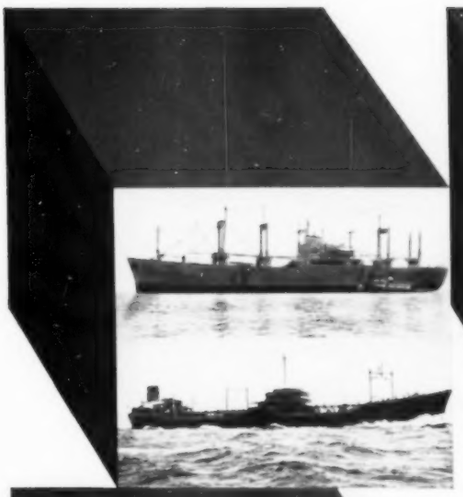
Continued research on the generation of static electricity in the pumping and storing of oil products has led to the development of a powerful anti-static additive, traces of which are sufficient to prevent the building up of dangerous electric charges.

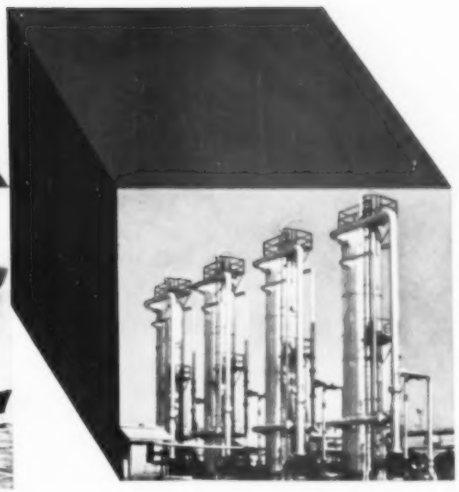
Consumers are steadily becoming aware of the improvements which have been made in kerosine heating and cooking appliances, as well as of the economy which can be achieved by their use.

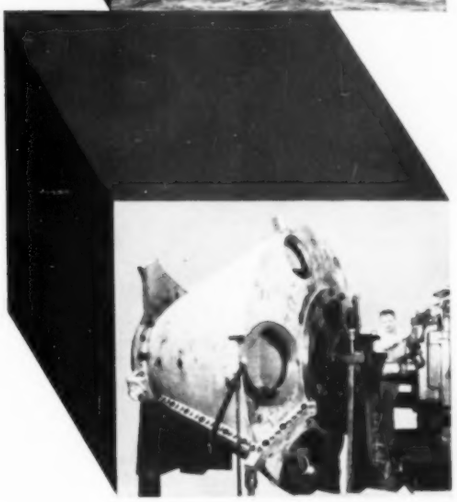
Chemicals from Petroleum: The Royal Dutch Shell group of companies is one of the largest producers of chemicals from petroleum raw materials in the world, and its scale of operations has now secured for it a place among the 12 largest chemical companies in the noncommunist world, when judged by the criterion of gross sales.

The principal chemical-producing plants operated by Shell are in North America (both the USA and Canada) and in western Europe. Large petroleum chemical plants are located in the United Kingdom, The Neherlands, France, and western Germany. Within the past year, Shell has announced the construction of chemical plants in Australia, which will soon be in operation.

During the four years since the Fourth World Petroleum Congress, very rapid progress has been made in the development of petroleum chemical manufacture, particularly in western Europe, where output between 1955 and 1958 had more than doubled from some 950,000 tons to an estimated level of some two million tons. These figures include inorganic chemicals made from petroleum and natural gas, such as ammonia, sulfur, and carbon black, as well as organics. In North America, output is estimated to have increased between 1955







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and 1958 by some 2½ million tons to a present level of just over 13 million tons. While this is an increase in total size of some 2½ times greater than the increase in western Europe, the gain in North America was only some 24% over the 1955 level, clearly indicating the slower growth rate of the much more mature industry in North America.

Shell has continued to play an important part in these developments; and now has investments in chemical plants at least double in size of those of any other oil company in the world which participates in the manufacture of chemicals. In the past few years, the range of products has been extended by adding many new chemicals to the range, so that today Shell makes and sells chemicals representative of almost every sector of the petroleum chemical field.

In the production of chemical solvents, Shell has continued to expand capacity, and new plants have also been built at Norco (Louisiana) in the USA and Bèrre in France. Shell is now probably the world's largest producer of synthetic chemical solvents in the noncommunist world, with nine production centers in five countries. Synthetic detergents are also an important branch of the petroleum chemical industry, and Shell is one of the world's largest suppliers of raw materials for their manufacture. Since 1955, the large plant for the production of detergent alkylate at Shell Haven in the United Kingdom has been in production, and other plants were brought onstream in 1958 at Montreal (Canada) and Bèrre (France). A further plant is under construction at Geelong in Australia.

In the important and rapidly growing field of chemicals for agriculture, Shell is playing an important role. Of particular importance is the production of the powerful group of insecticides, aldrin, dieldrin, and endrin which, together with the new organo-phosphorous compound "Phosdrin," an insecticide first introduced in the USA in 1956, makes Shell one of the world's leading insecticide manufacturers. Shell also produced two other important pesticides for use in the soil against plant pests, DD and Nemagon soil fumigants, both of which are contributing to improved crop yields in many parts of the world. Apart from the protection of crops with pesticides, and the important contribution to public health and hygiene, Shell also contributes to increased agricultural production through the supply of nitrogenous fertilizers. New plants include a unit to produce urea, a solid fertilizer of very high nitrogen content, at Ventura (California) in the USA, which was started up in 1956, and a new plant for complex nitrogenous fertilizers just being completed at Shell Haven in the UK. These units supplement output from older plants located in The Netherlands and the USA.

Synthetic chemicals from petroleum in which the Royal Dutch Shell group of companies has an important position include glycerin, where Shell was the pioneer. The first synthetic glycerine plant outside the USA was started up by Shell at Pernis in The Netherlands during 1958, and a new synthetic glycerin plant at Norco in the USA is now under construction. This unit will make use of a new process developed by Shell involving the use of hydrogen peroxide and acrolein, a highly reactive chemical. Ethylene oxide and its derivatives, such as the glycols and ethanolamines, are to be made on a large scale in a new plant at Carrington in the UK which has recently been completed. This unit employs a direct oxidation process for ethylene.

The most rapid advances in recent years have been in the field of plastics, resins, and synthetic rubbers, and here Shell has made its greatest efforts in the development of new products and the consolidation of its position. With the epoxy resins, outstanding in their resistance to attack and in their adhesion, Shell has made great progress, and new plants have been built or are under construction in Canada, West Germany, France, and Australia, and extensions added to the units in the UK, The Netherlands, and the USA.

Shell has acquired control of a polystyrene plant in the UK, and has initiated the manufacture of foamed polystyrene board at this factory. Extensions have also been made to the polyvinyl-chloride plant in The Netherlands, and to the polyethylene plant in West Germany, in which latter Shell has a joint interest with a German chemical concern. Plans have also been announced for the construction of a large plant at Carrington in the UK to produce polyethylenes and polypropylenes, at the location where a small unit has been in operation for some time producing high-density polyethylene.

Shell is also active in the synthetic-rubber field. Production of SBR rubber will be started in The Netherlands in a 50,000-ton-per-year plant, due for completion in 1960; and the first commercial production of polyisoprene, a synthetic product duplicating natural rubber, has recently been announced at the Torrance plant in California, USA.

Looking to the future: In the second half of the 20th century, the world is conscious more than ever of the need to stimulate economic activity. This progress is dependent on energy—energy in the right form and at the right price.

During the past 30 years, world energy requirements have more than doubled, but during this time there have been significant changes in the pattern of energy consumption. The share of coal has fallen from about four-fifths of the total in 1927 to less than half today. Increasingly difficult mining conditions are reflected in high production costs in Europe, while in the USA severe competition from other fuels has limited coal output.

Oil has provided the world with a readily transportable form of energy which can be used in a very wide range of applications.

During the past 30 years, the worldwide consumption of oil and natural gas has grown more than sixfold. Moreover, oil and natural gas have proved themselves to be most adaptable raw materials for the manufacture of organic chemicals. A new industry has rapidly grown up producing a host of revolutionary products from pesticides to plastics.

During the next half-century, it will prove still more difficult to increase coal output in most parts of the world, and the impact of hydroelectricity will be local rather than general. Despite the long-term promise of nuclear power, the bulk of the increase in world energy dmand will inevitably have to be met by oil, and natural gas, which alone have the flexibility to provide for almost every industrial domestic and transportation requirement from increasingly diverse sources.

In meeting these needs, the oil industry will have to expand vigorously; output will have to be at least doubled in the next 15 years. There is little doubt that sufficient oil is—or will be—available. Despite the greatly increased production of recent years, proved crude-oil reserves have greatly increased at all points. Moreover, the ratios of proved reserves to production have increased.

It is as certain as anything can be that today's proved reserves represent no more than a fraction of the oil which will ultimately be found to be recoverable from the earth's surface.

In recent years, much attention has been paid to methods of recovering a substantially higher percentage of existing oil accumulations by the application of heat. The Royal Dutch/Shell laboratory in Amsterdam has done important research on the effect of underground combustion of part of the oil and the effect of steam injection into the oil formation. It is expected that, with these methods, it will be possible to raise to about 50% the recovery percentage for heavy oil, which otherwise varies from 10% to 25%. Furthermore, the use of these methods may be considered in oil fields which cannot be exploited economically at all by conventional means, or are no longer so exploitable.

Tests on a practical scale are now in various stages of preparation and execution, both in The Netherlands and in the United States and Venezuela. If the new methods prove not only to be technically feasible, but are also economically comparable with the customary systems of production, the world's heavy-oil reserves could, at a very rough estimate, be doubled by advances in recovery methods alone.

As oil approaches its second century, it its confident of its ability to find, produce, and refine the oil and gas which the world will demand in a range of fuel and chemical uses which is virtually unlimited. And, in whatever developments the future may hold, the companies of the Royal Dutch/Shell group, which have always been in the forefront of technological progress, will undoubtedly play a leading part. END

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Kuwait Oil Company's NORTH PIER PROJECT

FROM 1946–55, the export of crude oil and products from Kuwait had risen to 52.44 million tons per annum (long tons) from 0.77 million tons per annum (long tons). From the increase in size of tankers, proposed and under construction, it was clear the existing port facilities at Mina al Ahmadi (a pier with eight oil berths and five submarine buoy berths) would be unable to cope with the probable future throughput. In 1956, it was decided to extend the port facilities by the addition of more loading berths. In July 1956, proposals for these additional facilities were submitted by consulting engineers, and it was decided a pier should be constructed some 4½ miles north of the existing pier, capable of exporting crude at 50,000 bbl per hour from any one of its five berths. The North Pier project was born.

Essentially, the project consisted of a pier L-shaped in the first instance but capable of extension to a T if necessary at a future date. The minimum depth of water at any berth is 60 ft at LWOST,* and the pier head is to be capable of berthing two 1,000-ft-long tankers on the seaward face and two smaller ones on the landward side of the pier head. To feed this pier, a new tank farm—the North Tank Farm—of 14 tanks of 35,000 tons (262,800 bbl) and one of 28,000 tons (210,000 bbl) capacity would be constructed on the ridge some five miles inland behind the North Pier. This tank farm would feed the new pier by gravity through three 40-in.—38-in. pipelines, the difference in level being about 350 ft. The design and engineering of the tank farm, gravity lines, and pier piping system was done by Kuwait Oil Co. Ltd., and the construction by local contractors. The design and engineering of the pier was entrusted to consulting engineers—Messrs. Rendel, Palmer & Tritton; and the construction of the pier was undertaken by George Wimpey & Co. Ltd. and Kuwait Bechtel Corp. The pier, with its 29,000 tons of structural steel—including over 3,100 piles, 3,000 tons of line pipe, and with 18,300 sq ft of net area to accommodate administrative, medical, industrial, recreation, and control buildings, fire protection, ancillary services, and the latest types of hose-handling gear—will be completed 21½ months from the word go, an extremely fast construction time for a pier reaching nearly a mile into the open sea.

*Low-water ordinary spring tide.

Kuwait Oil's North Pier project: Approach leg looking shoreward from recreation building.

The 4,754-ft approach leg is of simple trestle construction carrying a 12-ft timber roadway with four passing bays and a pipe track which can accommodate five 38-in., one 30-in., one 24-in., one 20-in., one 16-in., one 12-in., one 8-in., one 6-in., and one 2½-in. lines. Each trestle consists in general of a bent of two 14-in. by 12-in. BFB's† at 37-ft centers. In the deeper water, these are plated with two 16-in. by ½-in. plates. Each bent is capped with an 18-in. by 12-in. BFB, 55 ft long, and the bents are at 16-ft 0-in. centers. In the areas of the passing bays and the administration buildings, the number of piles per bent is increased to cater for the additional width. The structure is divided up into sections of 14 bays, each section being stiffened longitudinally by 6-in. by 6-in. tee **k**-bracing at capping beam level, and between each section is a structural expansion-contraction joint to cater for thermal movement. In addition, at the center of every other section, there is a structural anchor of a bent of two raking piles. The pipelines are carried on rollers fixed to the trestle bents to minimize friction, and expansion is catered for by using "sleeve-type" expansion joints every 1,000 ft with pipe anchors midway between the expansion joints. These joints and anchors are supported on special concrete-capped bents of raker piles completely isolated from the main structure. Thus the main approach leg structure is isolated from the pipelines, and either can expand or contract without affecting the other.

At a distance of 500 ft back along the approach from the pier head are situated the main administrative and industrial offices, and also the recreational facilities for tanker crews. The industrial block—which houses the fire pumps, electrical sub-station, transformer rectifiers for cathodic protection, compressor house, fitters shop, decompression chamber, instrument maintenance shop and store, paint store, fire-equipment store, and maintenance offices—is offset from the pipe track to the north with a floor level just above the top of the 38-in. pipes. The other block is a two-story building carried on portal frames over the pipe track. It accommodates the state medical quarantine section, complete with consulting room, pharmacy, treatment room, heatstroke room, quarantine room, and waiting room; the tanker crews recreational facilities and cinema; the administrative offices of storage and export; the ships agents' office; and the fire master's office. This building and the maintenance offices in the industrial block are airconditioned, the airconditioning unit being used as a heat pump for heating in winter. These buildings are steel-framed with concrete floors, and the cladding consists of an outer skin of aluminum sheeting, an air space, and an inner skin consisting of corrugated aluminium sheeting sandwiched between two layers of Asbestolux; the pitched roofs are of aluminum sheeting.

†Wide-flange beam.

Determined Men Built the Oil Industry

• Founder of Sun Oil Company, who proclaimed that "*the way to be successful in America is to give the people better quality and value,*" typifies the special breed who made oil a public servant.

JOSEPH NEWTON PEW was eleven years old when Colonel Edwin L. Drake's "Folly" turned the joke on townspeople who had ridiculed his perseverance in drilling for oil.

The impact of that historic event on young Joe Pew, helping out on his father's farm less than 50 miles away, is unknown. But some 10 years later he caught the "oil fever" that swept Oil Creek Valley.

Opening a real estate office at Titusville in his early twenties, he soon was trading in oil lands and mineral rights. Before his thirties he had gone broke, recouped his losses, paid off his debts, and launched a new enterprise—the commercial use of natural gas.

With E. O. Emerson as a partner, he formed the People's Natural Gas Company in Pittsburgh (the first large U.S. city to enjoy natural gas) and went on to engage in oil exploration, production and pipelining in Ohio and later in Indiana, Illinois and West Virginia. In 1894 the partners became owners and operators of a small refinery at Toledo, Ohio.

One of the things that troubled Mr. Pew most was the high cost of rail transportation for oil. The Lucas gusher at Spindletop in 1901 provided a source of crude oil near deep water. Mr. Pew moved quickly to establish a new refinery on deep water at Marcus Hook, Pa., and to acquire production and storage on the Gulf Coast near Beaumont.

JOSEPH NEWTON PEW

Now the mold was cast for the Sun Company, incorporated in New Jersey in 1901, and subsequently renamed Sun Oil Company. Technological experimentation and financial conservatism were to be characteristic parts of the mold. Others included balanced integration, emphasis on economical transportation, and the location of refineries adjacent to centers of dense population.

An overriding credo was Mr. Pew's stated conviction that "the way to be successful in America is to give the people better quality and value."

The forceful personality and indomitable spirit of Sun Oil's founder stamped an indelible mark on the company, and on his sons, John Howard and Joseph Newton, Jr., who have carried on the business since his death in 1912.

For its size, Sun Oil has contributed substantially to the advancing technology of the oil industry, and thus to the industry's ability to serve people better. It led in demonstrating that high quality lubricants could be made from naphthenic, as well as paraffinic, crude oil; it pioneered the long-distance products pipe line; its subsidiary, Sun Shipbuilding & Dry Dock Company, developed the all-welded tanker.

Sun Oil engineering made the Houdry Catalytic Cracking Process a large-scale commercial reality, providing for oil refiners their first chemical approach to the rearrangement of oil molecules. Most recently, Sun Oil took a giant forward step in the technique of motor fuel marketing with its development of the Custom Blending system, giving motorists for the first time an opportunity to fit fuels to the requirements of their individual cars.

These are the more notable among the many accomplishments of Sun Oil in building on the blueprint drawn by Joseph Newton Pew, one of the special breed of determined men who had the freedom to build the oil industry as an instrument of service to the American people • SUN OIL COMPANY, Philadelphia 3, Pa.

Pioneering Achievements of Sun Oil Stem from Founder's Credo

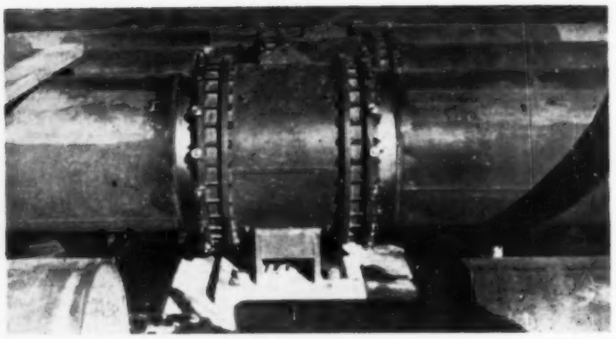
SOME SAID IT COULDN'T BE DONE but Sun made quality lubricants from naphthenic crude oil.

FIRST LONG-DISTANCE PIPE LINE for movement of products was a pioneering step made by Sun Oil.

SUN OIL ENGINEERING made large-scale catalytic cracking a commercial reality for oil refiners.

CUSTOM BLENDED MOTOR FUELS, a radically new concept in marketing, is one of Sun Oil's latest.

Pier head at west side, showing fixed fendering and gravity fenders.



Approach leg: 38-in. line expansion joints.

and in all buildings there is a false ceiling of Asbestolux sheeting for insulation purposes.

The cinema is the only part of the building cooled by a blown ducted system; in all other rooms the cooling is done by window units supplied with chilled water from the central water-chilling plant in the industrial block. In front of the building a car park has been supplied on the south side of the road, and access to the buildings is by two foot bridges rising from the car park and crossing over the roadway.

The pier head is 2,304 ft long and 126 ft wide, with two access ways 25 ft 0 in. wide; and a central pipe and cable track 76 ft wide is supported on 1,978 hexagonal Rendhex 4 piles 110 ft to 120 ft long and 145 twin 16-in. by 12-in. by 120-ft BFB fender piles. It is designed as a flexible structure with only vertical piling, but at both ends there are structurally separate strong points which accept the thrust after the ends of the pier have deflected 9 in. This arrangement overcomes the tendency of all flexible pier heads to be particularly vulnerable to tanker impacts at the end. The main framing of the pier which supports the pipe track and the roadway stringers has been designed as a long horizontal truss which distributes the horizontal and vertical loadings throughout a large area. To take care of high local stressing due to tanker blows, a secondary truss has been incorporated along each berthing face by incorporating extra bracings. As this pier is in an open roadstead, special attention was paid to the fendering; and, as gravity fenders had proved so successful under similar conditions at the South Pier, it was decided to adopt this principle for the North Pier, which has 29 groups of four gravity fenders, 16 groups on the seaward face and 13 groups on the landward face.

Each fender weighs approximately 75 tons in air and, with a stroke of about 4 ft, has an energy absorption of 144 ft-tons at mean high water. The fender group cum pier structure is then considered to have a capacity of 670 ft-tons. When a 100,000 dwt tanker is lying alongside, she will be resting against four groups. The design criterion accepted is that, when half-laden, she might draw off and surge back onto the fenders at a rate slightly in excess of 1 ft per sec at high water, the fender group absorbing 40% of this energy. The front faces of the fenders are protected with 12-in. by 5-in. greenheart rubbing strips bolted to 12-in. by 12-in. greenheart posts. Down the longitudinal center line of the pier head runs a 20-in. by 12-in. BFB tension member to distribute the longitudinal thrusts from the pipe anchors which, for convenience, have been arranged in groups through the whole head structure.

The approach roadway, pierhead access ways, and crossovers are all timber-decked with open 12-in. by 4-in. Douglas fir, and are designed to carry a 10-ton fire tender. Although the decks have been designed to carry a 10-ton fire tender, it was decided that fire fighting would be done from fixed installations supplemented by hand-held equipment, because it is never possible to guarantee free access along the pier head to fire tenders because of mooring ropes. Accordingly, the pier is covered from 24 monitors on 45-ft towers, each with its own individual 500-gal foam-compound tank and supplied with HP fire water from a ring main. In addition to these, there is a sprinkler system underneath the deck and pipe track for cooling and blanketing purposes, and hydrants are located at suitable places for fire hose and portable foam apparatus. The fire pumps—two four-stage electrically-driven vertical-spindle pumps of 1,400 gal per min at 620-ft head capacity—supply a 50,000-bbl fire water tank at the North Tank Farm, which is used for pressurizing the North Pier fire main and immediate first aid. It also acts as a reservoir from which the North Tank Farm fire pumps draw their supplies for pressurizing the fire mains there. Each of the five berths is capable of a maximum throughput of 6,750 tons per hour of crude and, in addition, bunkering facilities are provided.

It is estimated that the 40-in.—38-in. gravity mains are each capable of supplying at a rate of 50,000 bbl per hour, and provision has been made for installing two further mains at a later date if this is found to be necessary. The 24-in. HBFO line has an estimated capacity of 2,000 tons per hour, the LBFO line 1,000 tons per hour, and the MDO line 800 tons per hour. Each of these products is metered at each berth by positive-displacement meters, and an *in situ* meter calibration system is installed whereby meters can be checked during operations if necessary. Provision has also been made in the design for the metering of crude-oil throughput when meters of sufficient capacity are available.

The pier control office is situated on a tower over the southern strong point, and its first floor is 45 ft above the pier head deck. It houses on two floors the signal office on the top and, below the pier master's office, the pilot's room, marine general office, and the berth operators' supervisor's office. The building is cooled by window units supplied from a flameproof water-chilling plant at the foot of the tower, with a flameproof water heater which is used during the winter for heating. Further, there are three berth operators' offices on the jetty deck, containing an office with telephones, desk, etc., and shelter for the berth operating crew, wash-hand basin and lavatory. Each of these booths is cooled by its own self-contained flameproof veranda unit.

The construction of this pier in so short a time can be attributed to an excellent site organization, a very well laid-out stores and fabrication yard for the mass production of structural members, the design of welded joints with plenty of tolerance for fitting, and extreme accuracy of pile spotting and driving—on many occasions the piling barge being positioned to $\frac{1}{16}$-in. The design of the jetty was such that most of the work was repetitive; thus the fabrication yard, while proceeding at full bore, could build up a large stockpile of structural members ready for fabrication. The morale and spirit of the construction crews were kept at high pitch because of the visible progress which was made. The supply of material from the United Kingdom and other sources was in the main up to schedule, though there were the usual setbacks always experienced on a project of this size. Part of the success of this operation can be attributed to the enthusiastic support given by the Kuwait Oil Co.'s local executives to the consulting engineers' representative and staff; they all combined with the contractor to work together as a unit to effect the best possible job in the shortest time. END

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Preparing a photographic repeatability "jig" for a photograph of a cylinder head of a test engine at Shell's Thornton Research Center.

SHELL RESEARCH IN THE UNITED KINGDOM

In the United Kingdom "Shell Research Ltd., a company with headquarters in London,, carries out petroleum research at its research centers at Thorton-le-Moors in Cheshire and Woodstock in Kent. Thornton Research Center is mainly interested in applicational research on oil products for all marketing companies associated in the Royal Dutch Shell group of companies other than those in North America. The facilities at Woodstock make up the Agricultural Research Center, and it is here that all European agricultural research is concentrated.

Before the last war, research for Shell companies outside North America was carried on in the Amsterdam and Delft laboratories; but with the invasion of the Low Countries, these facilities no longer existed and a research group was set up in England. The major effort was on the problems connected with fuels and lubricants for aircraft engines, and the Shell Petroleum Co. installed a special aero-engine laboratory also at Thornton, which, though financed and staffed by company personnel, was operated for the duration of the war on behalf of the Ministry of Aircraft Production. In subsequent years, other laboratories were established at Thornton—one for research on general lubricating problems, another for the investigation of chemicals, and a third for the study of diesel fuels. In 1947, the work of these laboratories was coordinated, and Thornton Research Center came into being. Application research on products became the major concern of Thornton, while the laboratories reopened by NV de Bataafsche Petroleum Maatschappij in The Netherlands maintained their interest in all categories of research; concentrated their effort on process research, exploration and production, and on problems concerned with chemicals, process engineering, scouting, and fundamental research.

By 1954 the European economy was becoming free of the restrictions which were inevitable during the war and competition began to replace such arrangements as pooling. This freer economy, coupled with the increasing tempo of industrial activity by all marketing companies, intensified the need for application research. In recognition of this need, steps were taken to gear research to the calls which were being made on it, and "Shell" Research Ltd. was set up with the special object of administering and conducting the research effort. Thornton and Woodstock were taken over by this new company.

Thornton: Research at Thornton can be broadly divided into four major areas: fuels research; lubricants research; bitumen research; and general and fundamental research. The staff numbers about 1,000, of which 400 are qualified research personnel actively engaged on projects under investigation. During the past four years, the physical plant has undergone continuous expansion, the most important additions being a modern road-test laboratory, a hydrant fueling test installation for studying the handling of aviation turbine fuels, an analytical control laboratory and special facilities for working with radio-active materials.

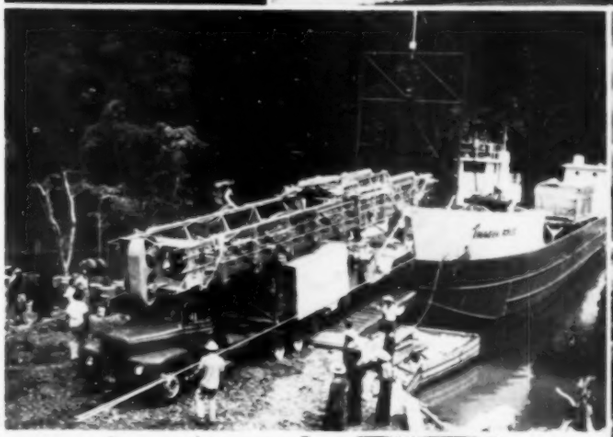
Currently, an extension program is under way which will continue through 1962. The plans call for a new engine lubricants testing laboratory and associated chemical laboratories, and a new applied physics laboratory which is designed to be one of the best equipped in the industry. Other projected facilities include metallurgy laboratories, a general research laboratory for products, a continuous combustion laboratory, and a new and expanded quarters for the technical information services.

Motor-fuel investigations in recent years have been concerned with the requirements of the new cars, including such factors as fuel sensitivity and the deterioration in performance resulting from deposits. Shell companies were responsible for the development of the ignition control additive, ICA which has alleviated the problems associated with lead deposits, and Thornton played a major part in the work which led to its adoption. The new road-test laboratory has contributed greatly to these motor-fuel investigations by providing facilities for extensive road testing. In one program alone, this laboratory permitted 300 fuel blends to be studied in 250 separate cars. It has facilities which provide for completely dismantling engines and for quantitatively examining and rating their components.

In the field of diesel fuels, work has been done at Thornton to improve the stability of certain types of diesel-fuel blends.

The quality control of aviation fuels must be exercised from the refinery to the aircraft, and with aviation turbine fuels many new problems have arisen—particularly in connection with fuel handling. In order to study handling techniques, an experimental hydrant fueling system was installed at Thornton in which it is possible to make

b



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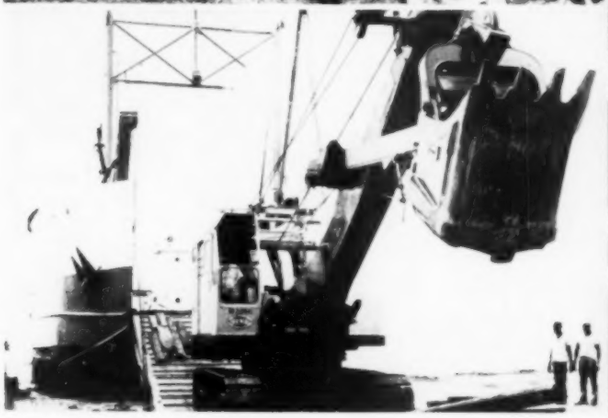

a

heavy

West India Line, since its inception, has specialized in the ocean transportation of all that is big, heavy, cumbersome, and generally difficult to move. This is accomplished by a fleet of newly constructed shoal draft vessels capable of discharging on beaches nearest jobsite as well as at dockside.

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(a) M V INAGUA ARROW, beached on the Pacific Coast of Panama for discharging. This is typical of her many trips since construction in 1956. These units are ready to operate NOW. No expensive export crating, no unpacking, no handling over crowded docks, no long overland transportation to jobsite from nearest deep-water port, no assembly problems. (b) M V INAGUA WAVE with a crane weighing 200 tons. This vessel, newly built in 1957, has saved many dollars for petroleum and construction companies working at points distant from deep-water ports. Those building processing plants, roads, and drilling oil wells in jungle areas along the coast and up tropical rivers will attest to this fact. (c) No longer is it necessary to cut cracking towers into sections making for expensive field assembly. West India Line can handle heavy pieces up to a length of 190 feet. (d) M V INAGUA ROVER delivering a drill rig up the Rio Dulce (with only six feet of water) at Livingston, Guatemala. From commencement of loading on the beach at Salinas, Ecuador, to completion of delivery of the entire rig next jobsite required a total of ten days.

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studies of filters, pumps, surge pressures, etc. Detecting and excluding water, even in minute quantities, is exceedingly important, and work at Thornton has made two notable contributions toward the solution of these problems. One is a water-sensitive portable indicator, and the other a failsafe quality control valve, the Fuel Monitor, which shuts off the flow of fuel when water is present.

Acid corrosion in engines has been a major factor in producing wear, and it was a problem to which Thornton paid particular attention, both in spark-ignition engines and diesel engines. As a result, the laboratories were able to recommend motor-oil formulations which reduced this type of wear to a minimum. Also the study of wear of other types is included in the research of lubrication.

Engine lubrication research has been greatly facilitated by the radioisotope technique, and "Shell" Research was first in the United Kingdom to use radioactive piston rings in test engines. Thornton has refined this technique so that continuous measurements of wear can be made in a test car under actual driving conditions, and it is now possible to obtain information on engine wear which is not available by any other method. In the case of diesel engines, the use of additives in the lubricating oil has led to an increase in the overhaul period from 60-70,000 miles to 200,000 miles. Also for diesel engines, Thornton has developed a running-in compound which accelerates the breaking-in period. The additives incorporated in this compound is a special combination of polishing agents which are an integral part of the compound.

Very promising results are being obtained as a result of studies Thornton is making on metal-working lubricants. An entirely new approach to the formulation of rolling oils shows promise of greatly speeding up the rolling operation and improving the surface finish. Incorporated in these new lubricants are special compounds which come out of solution at predetermined temperatures. In the aviation field, work at Thornton has contributed to the successful formulation of a line of extreme-temperature-resistant greases which are meeting the needs of the new generation of turbine-powered transports.

For the past several years, Thornton has been studying lubrication problems which can be expected in nuclear power stations. A cobalt-60 source of gamma radiation was installed to provide information on the effects of radiation on petroleum lubricants. As a result of this work and similar work at the laboratories of other companies of the Royal Dutch Shell group of companies, the first commercially available range of radiation-resistant lubricants for nuclear power plants, known as Shell APL Series, was introduced in 1957. These products are in regular use at Britain's atomic-energy station at Calder Hall and at the UK Atomic Energy Authority's Research Establishments at Harwell and Dounreay and at the authority's laboratory at Windscale. In addition to their use in the UK, Shell APL grades are being supplied to a number of nuclear research establishments in France, Denmark, Norway, and Sweden.

Shell Research is in close touch with Shell Tankers Ltd., and provides technical assistance when possible. A major technical problem in this field is that of corrosion in the cargo and ballast space of tankers. Since the war, the extent of the problem has increased not only by the increases in total tonnage, but by the increase in the size of tankers which may exceed 100,000 dwt. It is estimated that, without protective measures, a fleet the size of that operated by the various Shell companies concerned would suffer a loss of £2 million per annum because of corrosion. The most promising method of protecting cargo tanks at the moment appears to be based on the application of surface coatings made with Shell epikote resins. Such coatings are particularly attractive for new ships where surface preparation is not so difficult as in tanks which have already been subjected to corrosion. Studies of more orthodox materials like bitumen-based coatings are under way with particular reference to the protection of permanent ballast tanks.

Examining conditions of a bituminous surface during a low-temperature test on a model road, part of road-test facilities at Shell's Thornton Research Center.

Attention is also being paid to the protection of the sterns and propellers of tankers by the trailing anode technique, and the results obtained so far appear to be most encouraging.

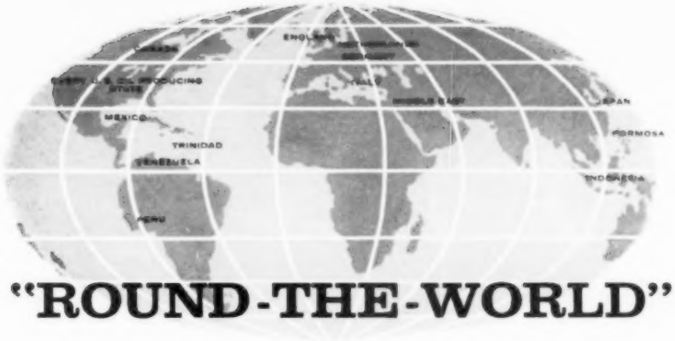
Woodstock: For many years Shell companies have been close to the agricultural community not only as suppliers of fuels and lubricants, but as suppliers of chemicals. During the past 15 years, control of pests has been revolutionized by the introduction of organic chemicals, and Shell companies have pioneered in the development and application of these highly effective insecticides, fungicides, and herbicides. This effectiveness is largely due to the extensive research which has preceded the marketing of these compounds. About five years ago, the importance of centralized and coordinated research effort in this field was recognized, and all European agricultural research was placed in the hands of Shell Research and carried on at the Woodstock Agricultural Research Center. Here some 50 to 60 scientists devote full time to the search for new agricultural chemicals, initiate the development of new products and seek solutions for specific problems which arise in the field. Shell Research keeps in contact with related research going on at the Shell Development Co.'s agricultural laboratory at Modesto, in California.

It was owing to investigations made at Woodstock that the best use could be made of dieldrin, the most successful insecticide for the control of locusts in the Middle East. Woodstock made a thorough study of the reaction of locusts to this chemical, with the result that the most effective method and rate of application could be employed. In the course of this work, considerable data were recorded which have contributed much to our knowledge of control procedures.

One of the important fields of investigation at Woodstock is concerned with the duration of the effectiveness of sprays, dusts, etc. Laboratory findings are then followed up by field studies. For example, following discussions with the World Health Organization on methods of controlling mosquitoes, a Woodstock entymologist spent considerable time in East Africa working with local health authorities on the behavior of an insecticide when applied to the walls of mud huts. These studies supplemented the laboratory findings and provided an understanding of the role played by local conditions of heat, humidity, and soil chemistry in the application of the chemical.

Woodstock has had to develop and modify techniques for determining trace quantities of chemicals on crops. It has made many contributions to these techniques, and is constantly receiving requests for guidance from government bodies and consumers.

A new biological laboratory is scheduled for completion at Woodstock in 1960. Removal of the present biological laboratories to these new quarters will mean that space will be released into which the research on chemicals can expand to cope with the increasing effort in this field. END



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You are cordially invited to visit the Petrolite Corporation Exhibit at the 5th World Petroleum Congress.

Animated displays, scale models, photomicrographs, flow charts and maps will demonstrate some of Petrolite's scope and depth of service to petroleum producers, refiners and transporters throughout the free world.

We think that this assembly of display features and product information will be both interesting and informative. We hope, too, that it will help you to discover profitable answers to some of your own petroleum problems. Here are some of the things you'll see and learn about:

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- Part of the Tretolite exhibit recently on display in the Chemicals and Synthetics Exhibit sponsored by the U. S. Dept. of Commerce in Washington, D. C.
- Scale model of the TRETOLITE* Desalters that are on the job all over the world removing salt from crude with efficiencies in the 98-100% range.
- Molecular models of some of the more popular TRETOLITE treating chemicals.
- Animated demonstration of a KONTOL* Corrosion Inhibitor "squeeze treatment".
- Animated demonstration of FLUDEX* Water Flood Additive Treatment.
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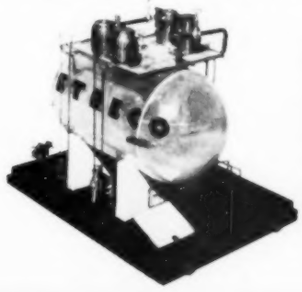
Specialized Electrical Processes and Equipment from the PETRECO *Division*



- Scale model of an all-electric PETRECO* Desalter, showing how salts, solids and residual BS & W are continuously and automatically removed from crude oil.
- Flow charts and photographs to demonstrate ELECTROFINING* efficiency in removing acids, H_2S, mercaptans, cresols, sulfur compounds, arsenic, lead, etc., from light to middle distillates.
- 3-D flow diagram that describes a modern, low-cost way to sweeten gasoline, jet fuel, kerosine and heating oil without loss of volume and without stream and air pollution.
- Photomicrographs that "take you in close" to show how a PETRECO* Precipitator effectively removes sediment from petroleum.
- PLUS other displays of interest to the petroleum industry.

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Four Decades Of Petrochemicals

by Peter W. Sherwood*

In terms of hydrocarbon consumption, the petrochemical industry is a minor factor. In 1957, its raw material and fuels requirements accounted for somewhat less than 4% of America's hydrocarbon production. But, in terms of chemical output and dollar volume, an entirely different story is told. Thus, in 1958, total output in petrochemicals is estimated at 42.5 billion pounds, or 27.9% of total USA chemical production. The combined value of petrochemicals produced during 1958 is reported at $5.2 billion, or 56.6% of total chemicals valuation.

Among organic chemicals, petroleum-derived materials are even more preeminent. They account today for 80% of USA output vs. only 45% in 1945.

Petrochemicals have reached their present leading position in the chemical field from a start which dates back little more than one-third of a century. It is difficult to tell—and also somewhat academic—just who produced the first chemicals from petroleum sources. Most authorities, however, date the origin of the petrochemical industry from two operations: Esso's production of isopropanol at Bayway, N.J., in 1918, and Carbide and Carbon's ethylene-glycol operations which began semicommercially at Clendenin, W. Va., in 1920.

These two chemicals were a particularly fortunate choice for the young industry. Both have shown continued growth and, even as of this date, ethylene glycol is the largest ethylene consumer, while isopropanol still constitutes the chief chemical market for propylene.

The production of ethylene glycol and isopropanol ushered in an era in which olefins were the only important hydrocarbon resources of the petrochemical industry. Advantage was thus taken of the most reactive hydrocarbons which were uniquely available from petroleum sources (ethylene formed in the course of byproduct coke-oven operations has never been a significant factor in the USA chemical picture).

Subsequent progress of the petrochemical industry has taken three courses: (1) expansion of total markets for established petroleum-derived chemicals; (2) inroads of petroleum raw materials into chemical markets which had traditionally relied on different sources of supply; and (3) development of new commercial chemicals from a petroleum raw-materials base.

1. Expansion of Total Markets: Increase in the demand for an established chemical is due to three developments: (1) the rise in the economy as a whole; (2) raised per-capita consumption of the chemical in a given market; and (3) development of new outlets for the chemical. Of these three factors, only the last two can be significantly influenced by any single segment of the industry. The extent to which such influence may be exerted is largely a measure of technical alertness. Technical service will uncover new areas for product application; process advances will show the way to a lower manufacturing cost and, in result, a product which can be more attractively priced.

Applying such techniques, the petrochemical industries have chalked up a most successful growth record for established chemicals. Between 1929 (or first year of substantial output) and 1956, the average annual growth rates of some of the more important products in this category were as follows: *40% per year and over:* polyethylene, styrene, butadiene, petroleum-based synthetic detergents; *30-40% per year:* pentaerythritol; *20-30% per year:* vinyl chloride, urea, xylene, perchloroethylene; *15-20% per year:* petroleum polymers, synthetic methanol, phthalic anhydride; *10-15% per year:* acetic anhydride, acetone, ethylene oxide, formaldehyde, phenol, synthetic ammonia.

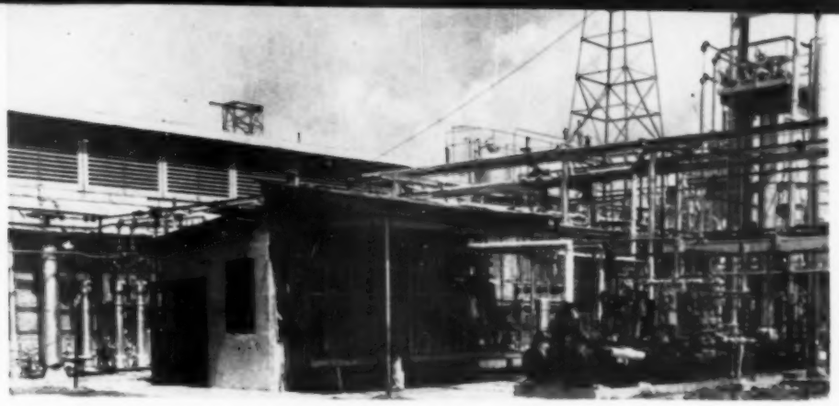
Only a relatively few successful petrochemicals have shown an average growth rate below 5%. Included in this group are ethyl acetate (2%), glycerin (2.7%), ethyl alcohol (3%), and benzene (3%). It is significant, however, that the rate of growth of these products from petroleum stocks has been very much greater. The reason here is that petroleum-based feed stocks have taken over from other raw materials, an aspect which we shall discuss below.

By way of comparison, we might mention that the gross national income in the United States has risen by an average 3.5% per year between 1929 and 1956—(in terms of constant-dollar value). Petroleum demand has experienced an average yearly growth of 6% during the same period.

An important factor here is that the petrochemical industry has been able to serve as the most economic supplier to the rapidly grown plastics, synthetic-fibers, and surface-coatings industries. Beyond that, however, the end-uses for petrochemicals reach into nearly every industry. Again, the point can best be demonstrated by a few individual illustrations, as shown in accompanying Table 1. The list is far from exhaustive.

* Chemical Engineer, White Plains, N. Y.

First ethylene utilization for ethylene glycol manufacture was at Clendenin, W.Va., at former natural-gasoline facility (photo, courtesy Union Carbide Corp.).



First American producer of oxo alcohols from olefins was Esso Standard Oil Co.'s Baton Rouge, La., unit.

Over the years, there has been considerable shift between industries as outlets for a given chemical. Styrene, which became commercially available during the early 1940's for near-exclusive use in the synthetic-rubber industry, finds today its chief outlet in the manufacture of plastics. Similarly, ethylene dichloride's principal outlet was, until a few years ago, in the production of antiknock compounds. Today, vinyl-chloride synthesis consumes upward of 70% of ethylene-dichloride output.

As second controllable factor in raising the total market for an established chemical, we have mentioned the manufacturing cost, which is reflected in the product's price. Here, too, considerable progress has been made by the petrochemical industry. The approach takes two courses: (1) the day-to-day emphasis on improving efficiency, which leads to significant cumulative savings; and (2) the more spectacular development of new processes which rest on a less costly raw-material base, or which provide significant savings in terms of by-product credit or improved product yield.

It is interesting to note that the introduction of such new, more economic processes into the petrochemical field has rarely meant rapid obsolescence of the older method. The newer process finds its place in the industry and, in due course, takes up the lion's share of new expansion.

Some of the more significant innovations of this type may be cited. Synthesis of acetaldehyde, once relying principally on acetylene, starts today almost exclusively from ethanol (plus some direct oxidation of paraffins). Acrolein is made by Union Carbide by the condensation of formaldehyde with acetaldehyde, while Shell's newer plant employs direct oxidation of propylene. Adipic-acid manufacture has been shifted from oxidation by means of nitric acid to the use of air for the first step in the oxidation of cyclohexane.

Particularly spectacular have been advances in the technology of manufacturing acetone. Formerly obtained only by conversion of isopropanol, it is today also manufactured as coproduct in a phenol synthesis process first commercialized in 1952 (by Shawinigan Chemicals), as byproduct in Shell's completely new process for the production of hydrogen peroxide and glycerin, and as one of many products in the partial oxidation of butane as practiced by Celanese Corp.

Ethylene oxide, a mainstay of the industry, is shifting from the classical chlorohydrin route (which consumes chlorine) to the direct oxidation of ethylene by air or oxygen, a French process pioneered in this country by Union Carbide Corp.

Production of synthesis gas (for ammonia and methanol) from methane relied originally on reaction with steam in externally fired furnaces. Since the end of World War II, there has been a shift toward the use of oxygen plus steam in a thermally balanced reaction system.

A special situation exists in the partial oxidation of paraffins (notably butane), as practiced by Celanese Corp. There are two versions of the process. One of them (in the liquid phase) yields acetic acid preferentially, while the other (in the vapor phase) leads to a mixture of low-boiling oxygenated chemicals, such as acetone, acetaldehyde, etc. A form of direct oxidation of methane was practiced very early by Cities Service Co. Other versions of alkane oxidation have been the basis of plants built by various other producers. But, today, only Celanese and Gulf Oil Corp. have retained this intrinsically attractive, but highly complex, process and the method is responsible for only a small share of total output of the oxygenated chemicals which it yields. Only in the case of acetic acid does direct oxidation of C_3-C_4 hydrocarbons account for 20% of total production.

2. Inroads into Alternative Sources: Much of the growth of the petrochemical industry has come by displacement of the previously conventional sources of supply. Here, advantage is taken of the petroleum industry's raw-materials position which is peculiarly favorable for the manufacture of large-scale industrial chemicals.

Three reasons have been responsible for the petrochemical industries' growth in this direction. One such reason is the inability of an alternative source to meet the growing demand for a particular chemical. This has been the case in the supply of benzene, toluene, and xylene which were, prior to World War II, wholly derived from byproduct coke ovens and tar distillation. Today, the petrochemicals industry supplies about one-third of the domestic benzene market, 75% of toluene, and 91% of xylenes demand.

The second reason for a shift has been purely a price consideration. Thus, fermentation processes have almost completely given way to petrochemical synthesis as a source of acetone, n-butanol and, less completely, as a source of industrial alcohol. Ethanol itself has ceased to be important as raw material for the production of butadiene, which is obtained today only from butane and butene.

(Continued on page 168)

Table 1 End Uses for Petrochemicals

Industry	Main Market for	Secondary Market for
Synthetic fibers	Adipic acid, acrylonitrile, terephthalic acid, caprolactam	Ethylene glycol
Semisynthetic fibers	Acetic anhydride, carbon disulfide	
Surface coatings	Glycerol, pentaerythritol, phthalic anhydride, vinyl acetate	Butadiene, vinyl chloride, styrene, isopropyl alcohol
Miscellaneous industrial chemicals	Acetaldehyde, acrolein, ethyl alcohol, hydrogen cyanide	Acetone, carbon disulfide
Plastics	Acrylic esters, formaldehyde, phenol, polyethylene, styrene, vinyl chloride	Adipic acid, ethylene glycol, phthalic anhydride, urea
Dyestuffs	Aniline	Phthalic anhydride
Pharmaceuticals	Methyl mercaptan	Aniline, glycerol, hexamethylene tetramine
Rubber	Butadiene, carbon black	Styrene, acrylonitrile
Dry cleaning	Perchloroethylene	
Plasticizers	Oxo alcohols	Phthalic anhydride
Detergents	Dodecyl benzene sulfonates, nonyl phenol	Ethylene oxide
Antiknock compounds	Ethyl chloride, ethylene dibromide	Ethylene dichloride
Fertilizers	Ammonia, urea	
Antifreeze	Ethylene oxide (as glycol)	Propylene oxide (as glycol)
Refrigerants	Fluorochloro hydrocarbons	Methyl chloride
Aerosols		Fluorochloro hydrocarbons
Tobacco		Glycerol

Pioneer plant for synthetic glycerin production from propylene by Shell Chemical Co., Deer Park, Texas.

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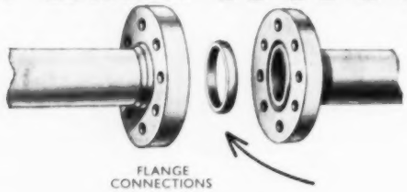

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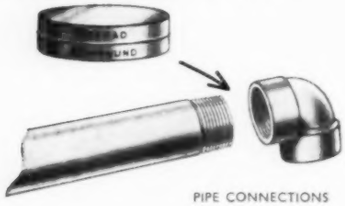

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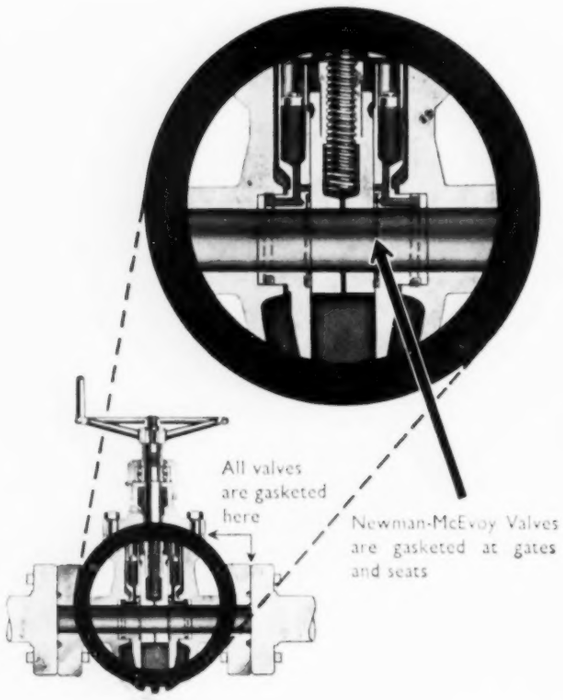

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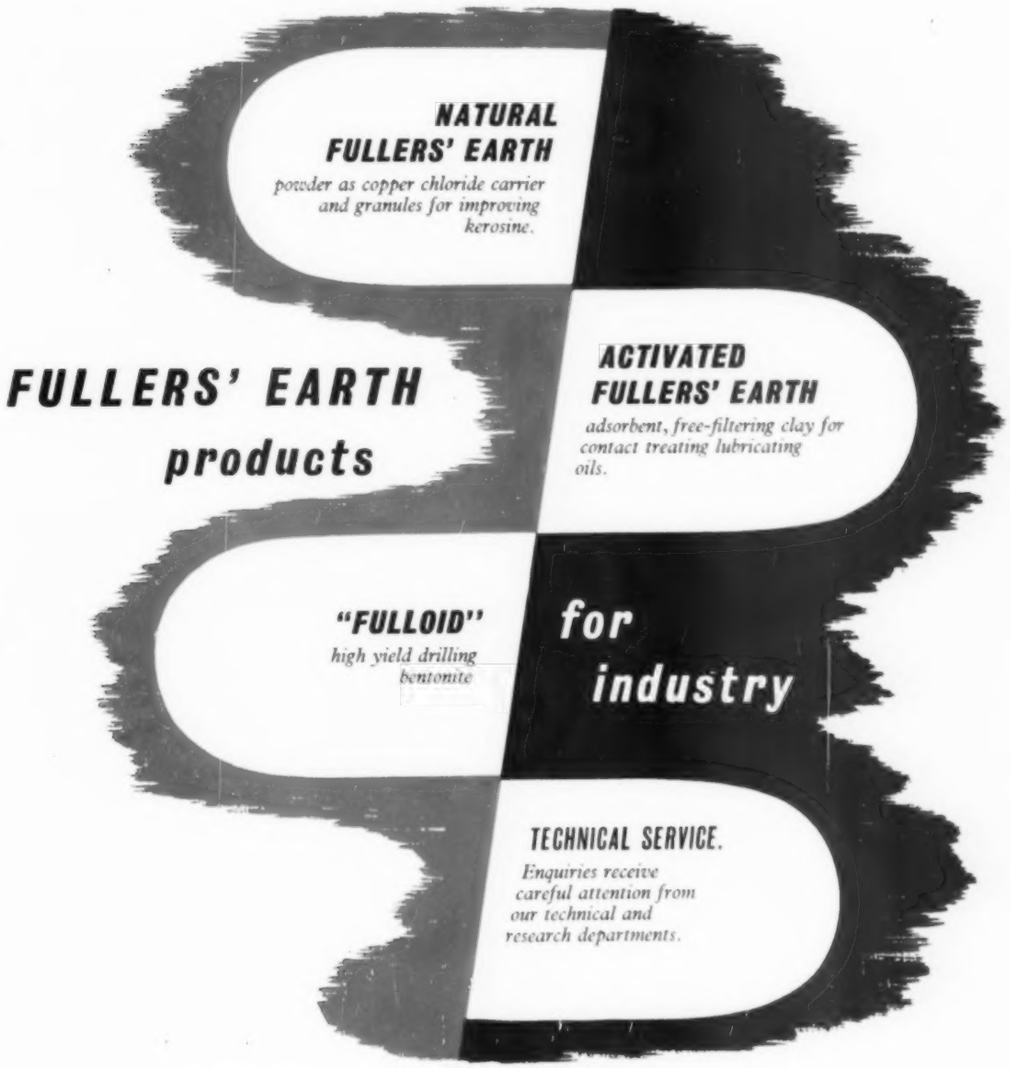

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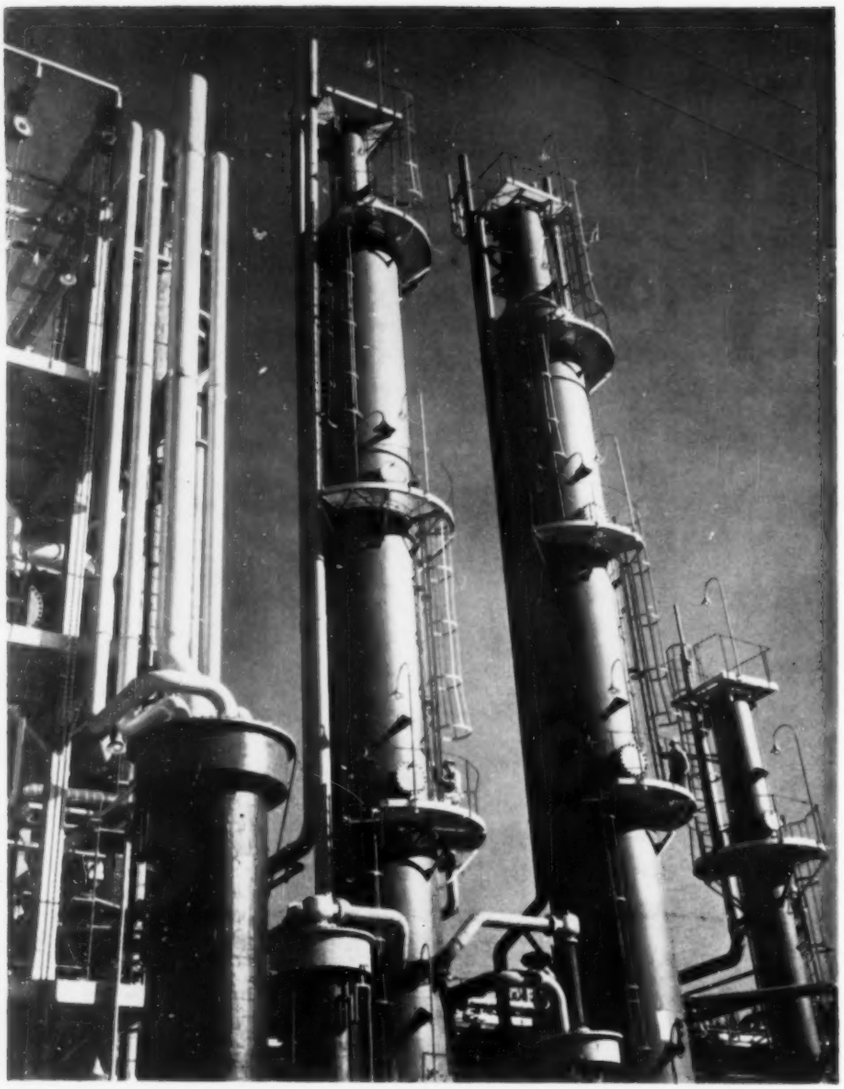


Monsanto Chemical Co.'s acetylene unit at Texas City, Texas.

Table 2 Basic Chemicals in Petrochemicals Synthesis

Chemical Product	Petrochemical Feed Stock	Classical Source
Acetaldehyde	Ethylene (via ethanol) of butane (by oxidation)	Acetylene (from lime and coke)
Acetone	Propylene (via isopropanol or cumene)	Fermentation
Acetylene	Methane plus oxygen	Lime plus coke
Ammonia	Synthesis gas from CH_4 or byproduct hydrogen from reformers	(Sea hydrogen)
Benzene	Naphtha reformate	Coking and tar distilling
N-Butyl alcohol	Acetaldehyde (cf. above) propylene (via Oxo route)	Acetaldehyde (cf. above), Fermentation
Carbon disulfide	Methane plus sulfur	Coke plus sulfur
Carbon tetrachloride	Methane or propylene	Carbon disulfide
Cresols	Isopropyl toluene	Coking operations
Formaldehyde	Methanol (q.v.) oxidation of paraffins	Methanol (q.v.)
Glycerin	Propylene	Soap manufacture and fat splitting
Hydrogen	Methane plus steam (and oxygen). Byproduct of catalytic reformers	Coke-steam reaction Iron-steam reaction Electrolysis of water
Hydrogen cyanide	Methane plus ammonia and air	Sodium cyanide
Hydrogen peroxide	Isopropanol, or alkyl anthraquinones	Electrolytic methods Thermal methods (barium peroxide)
Methanol	Synthesis gas from hydrocarbons. Oxidation of paraffins	Synthesis gas from coke
Phthalic anhydride	Ortho-xylene	Naphthalene (from byproduct coking)
Sulfur	H_2S from sour hydrocarbon gases	Frasch mining
Toluene	Naphtha reformate	Coking and tar distilling
Vinyl chloride	Ethylene or methane-based acetylene (q.v.)	Acetylene (q.v.)

(Continued from page 165)

Still another consideration which has made the petrochemical industry an effective competitor with alternative sources has been relative price stability. Here, the classic example is glycerin. As a byproduct of soap manufacture, the price of this chemical had been notoriously dependent on fluctuations in the cost of fats which serve as raw material in the classical manufacturing process. The introduction of propylene-derived synthetic glycerin in 1948 has permitted the writing of long-term supply contracts at relatively stable prices. In the open market, too, the arrival of synthetic glycerin has had the effect of improving price stability and of exerting a general downward pressure on glycerin price (except during the Korean action). Price in late 1958 was quoted at 27.5 cents per pound in tank cars. This compares with 39 cents in 1948.

The petrochemical industry's origin rests in syntheses of organic chemicals from olefins. Today, its raw-material base for organic chemical products takes in the following additional areas: *acetylene*—traditionally obtained from lime and coke; *aromatic hydrocarbons*—traditionally obtained from coke ovens and tar-distilling operations; *paraffinic hydrocarbons*—traditionally a petroleum product.

Beyond that, the industry now enjoys a strong position in the field of certain inorganic chemicals. Here, the most important members are ammonia and sulfur.

Ammonia itself is, of course, principally dependent on a low-cost supply of hydrogen. Chief source of this gas is synthesis gas, a mixture of carbon monoxide and hydrogen which finds other important end-uses in the production of methanol and of oxo alcohols.

The classical source of synthesis gas (or water gas) is the reaction between steam and coke. The petrochemical industry's entry as a source of synthesis gas was facilitated in a period when prices of gaseous hydrocarbons were low (e.g., immediately following World War II when natural gas was available in the Brownsville, Texas, area for 5 cents per mcf). Steam reforming of methane—coupled in some cases with partial combustion by air and, at a later date, by tonnage oxygen—took over the controlling position as source of synthesis gas and hydrogen. In 1942, natural-gas reforming accounted for 11% of installed ammonia capacity in the USA, which was 830,000 short tons at that time. By 1949, the share of natural gas had risen to 38% of ammonia capacity (1.6 million tons). By 1956, ammonia capacity had reached 4.8 million tons, and 79% of this amount was dependent on synthesis gas from methane.

The widespread adoption of catalytic naphtha reforming processes during the 1950's made available cheap byproduct hydrogen which has now become the most rapidly growing source of ammonia. By 1956, byproduct hydrogen already was accounting for 10% of installed ammonia capacity.

Elemental sulfur is the second most important inorganic product of the petrochemical industry. This element is recovered by the partial combustion of H_2S recovered from petroleum gases. A few plants devoted to this conversion were operated as early as 1929 (e.g., by Phillips Petroleum Co., at Crane). Sulfur recovery from petroleum sources did not, however, become significant in the United States until 1944, when the first modern unit of this type was taken onstream at McKamie, Ark. Since then output has grown to 646,000 long tons in 1957, 8% of total USA sulfur production during that year.

A list of chemical syntheses in which the petrochemical industry has taken over entirely or in part from other sources in the course of its short history would be a long one. Table 2 gives some of the more important basic chemicals in this category. The list can be expanded almost at will.

The era of the petrochemical industries has also seen one major project (at Brownsville, Texas) for the synthesis of liquid petroleum hydrocarbons themselves, using natural gas as feed stock. An important factor in the economics of the process was seen in the formation of large amounts of oxygenated hydrocarbons (acetaldehyde, ethanol, n-propanol, etc.) as byproducts. The project was unsuccessful for various technical and economic reasons, and was abandoned in 1957. (Parts of the plant were subsequently taken over by Union Carbide for other purposes.)

3. Development of New Commercial Chemicals: Since its early years, the petrochemical industry had added a large array of chemicals which had not previously been commercially available (except possibly at very much higher prices). Any list of the more successful chemicals in this group would certainly have to include the following:

Acetone cyanhydrin, acetophenone, acrolein, acrylonitrile, adiponitrile, allyl alcohol, allyl chloride, butadiene, diacetone alcohol, dodecyl benzene sulfonates, dodecyl phenol, epichlorohydrin, ethanolamines, ethyl benzene styrene, ethylene dibromide, ethylene dichloride, isobutyl alcohol, isobutyraldehyde, isoprene, mesityl oxide methacrylates, methyl ethyl ketone, methyl isobutyl carbinol, methyl mercaptan, nitroparaffins, *oxo* alcohols, polyethylene (high-pressure and low-pressure), polypropylene, n-propyl alcohol, propylene oxide and glycol, terephthalic acid, trichloroethane, vinyl chloride, vinylidene chloride.

By this type of diversification, a broad base of petroleum-derived industrial chemicals has been created. Their derivatives, in turn, add to the growth of the industry. Here, again, alternative sources often become competitive, and it is difficult to decide just where the petrochemical industry begins and other chemical process industries end. The question is, however, one of semantics, and the pressure for growth by diversification has had the effect of cutting broadly across industrial lines.

Outlook: The petrochemical industries still continue to accumulate momentum. Although cost of raw materials is rising as refinery processes compete for the same feed stocks, the requirements of the chemical consumer will certainly be met, since conversion of hydrocarbons to chemical products represents, in general, a greater degree of upgrading.

A recent study predicts that total output of petrochemicals will rise to 62 billion pounds by 1962 from 39.8 billion pounds in 1957; to 85 billion pounds by 1965—an average annual increase of 10%. The greatest boost is seen in aliphatics, with an estimated annual growth rate of 13%. Forecast for aromatics is set at 8% increase per year, while inorganic petrochemicals (including carbon black) are expected to expand by nearly 6% each year. Aside from the expected growth in established petrochemicals, several promising new products are now reaching the stage of commercial definition. In this area, the immediate future promises particularly favorable growth rates for linear polyethylene (which is, however, already overbuilt for some years to come), for polypropylene, and for propylene oxide which is afforded an important new outlet in the rapidly growing polyurethane plastics.

Methane-derived acetylene has long been on the threshold of wide adoption (it accounts today for about 20% of acetylene production), and its economics in a large production facility continue to be attractive.

Isoprene, produced today chiefly as a secondary monomer for butyl rubber, is expected to show much growth as synthetic polyisoprene rubbers reach commercial stature. The problem here is one of raw-material economics—probably not an insurmountable obstacle. Promise is shown by a new elastomer, a stereospecific copolymer of ethylene and propylene.

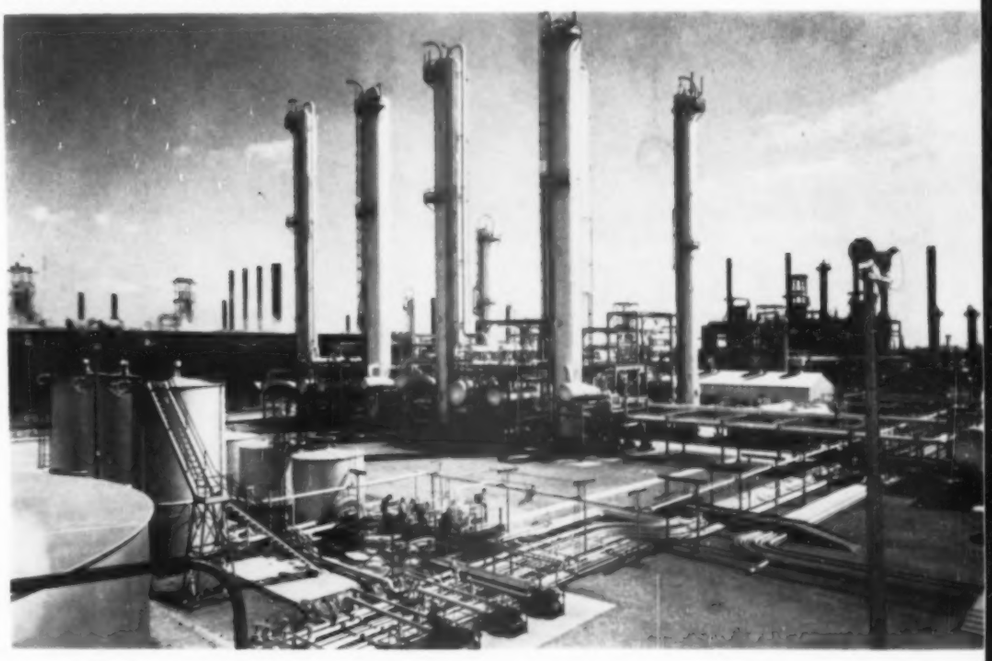
The demand for synthetic fibers will continue to push for more acrylonitrile, hexamethylene diamine, terephthalic acid, and the more recent large-scale entry, caprolactam. In this field, stereospecific polypropylene also offers promise.

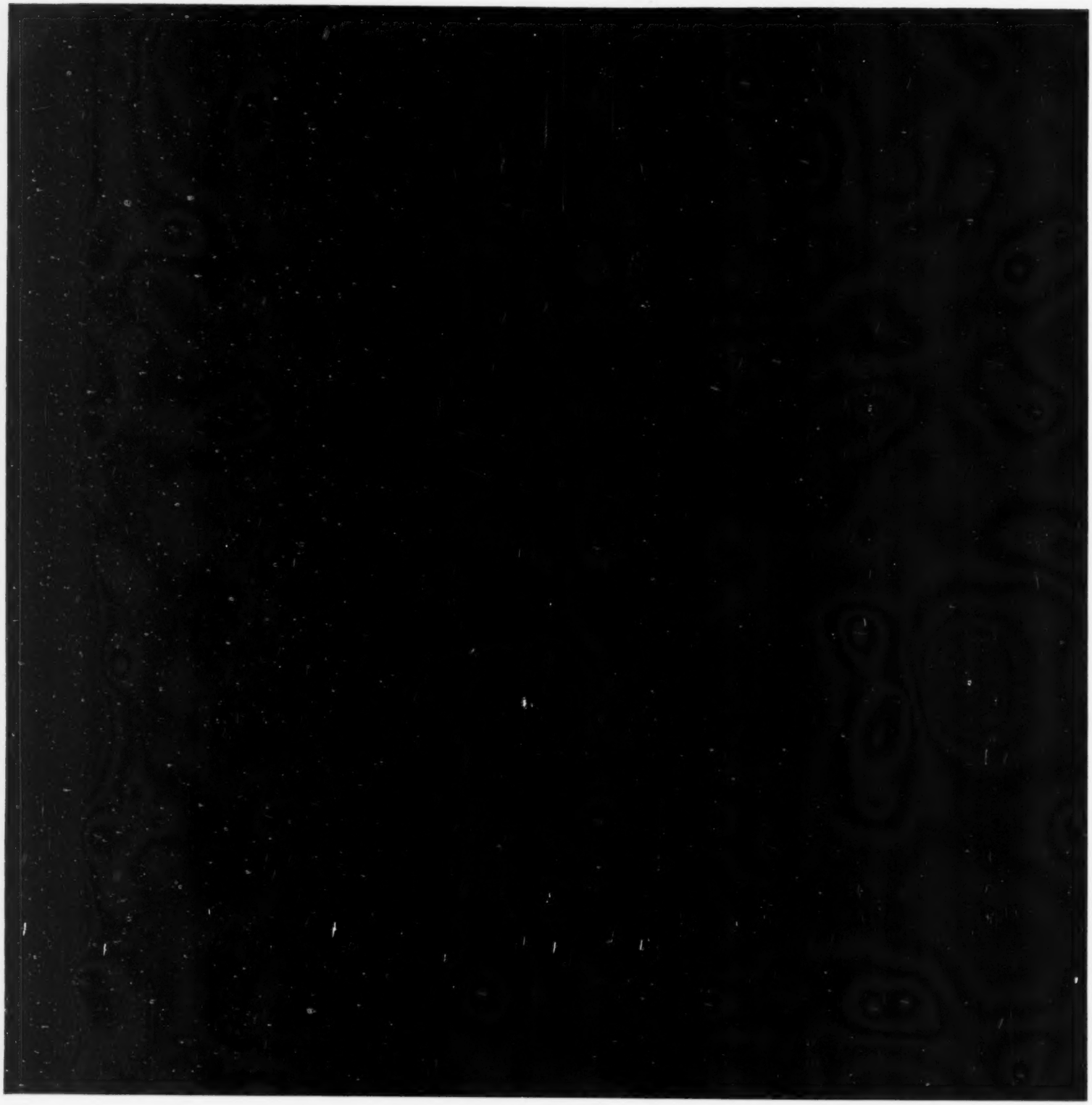
A recent study suggests that the petrochemicals industry will expand by 250% between 1957 and 1975. Among chemical process industries, this potential is rated second only to aluminum production (300%). It is well ahead of synthetic fibers (200%), plastics (140%), fertilizers, insecticides, pharmaceuticals (100%), and industrial chemicals or petroleum products (75%).

The combined growth potential and value improvement which has characterized the petrochemical industry during its first four decades may thus be expected to continue. These factors have been responsible for the avalanching number of companies which have entered the field. A count in late 1958 shows 209 USA plants engaged in the manufacture of organic petrochemicals; 114 plants produce inorganic chemicals from petroleum feed stocks, and 32 plants are engaged in the production of butadiene and copolymer synthetic rubbers.

At this time, the bulk of petrochemicals is manufactured by companies which are historically chemical operators. In increasing measure, the field is being entered by petroleum refiners who view petrochemicals as a particularly promising and natural direction for diversification. We may expect that this type of vertical integration into the chemical field from a position in petroleum raw materials will characterize the industry's development in the years to come.

Commercial manufacture of petroleum-derived benzene began, April 1947, at Shell Oil Co.'s Wilmington, Calif., refinery.





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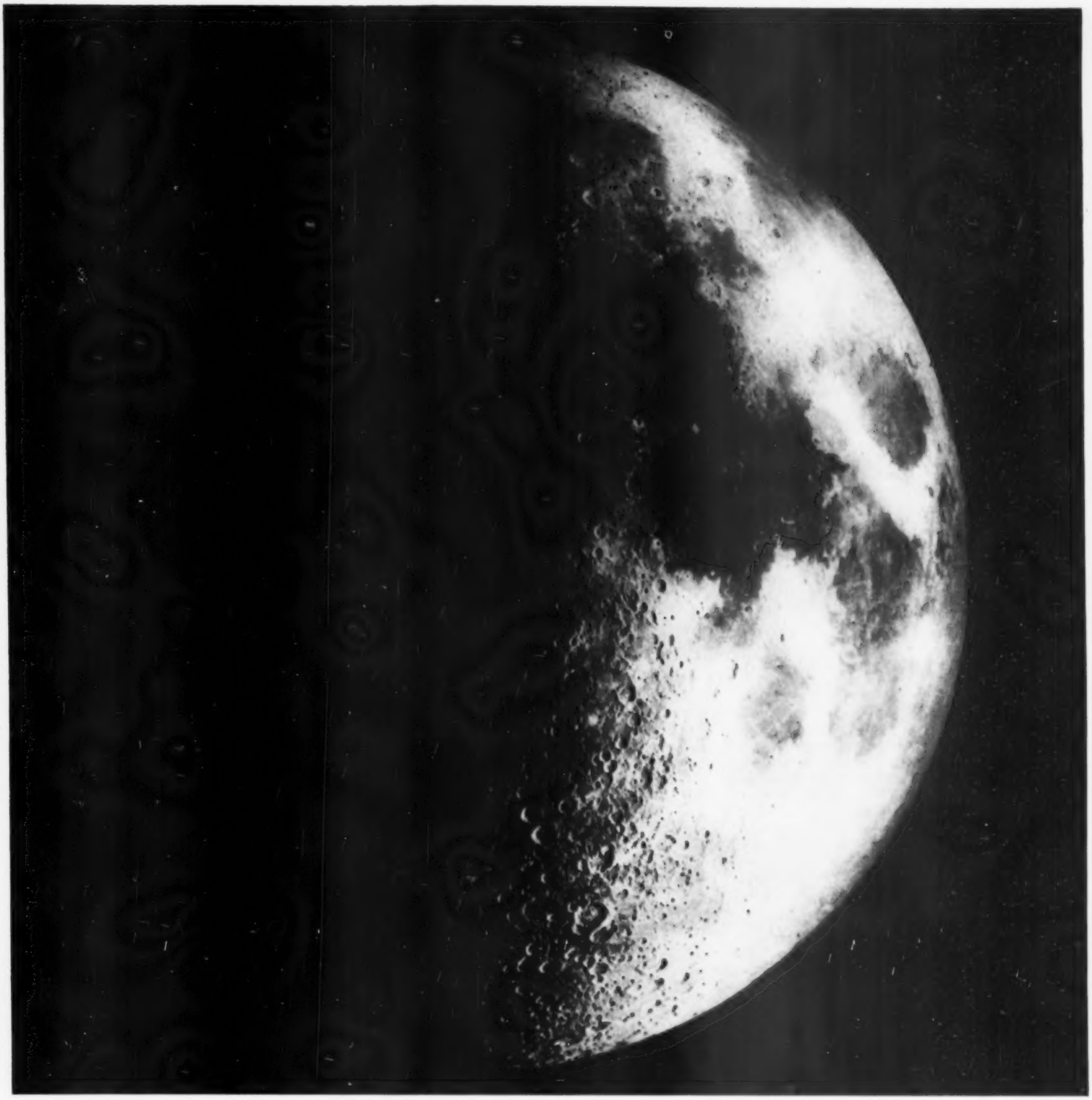

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Standard Oil Company (New Jersey) Esso

BRITISH PETROLEUM EQUIPMENT

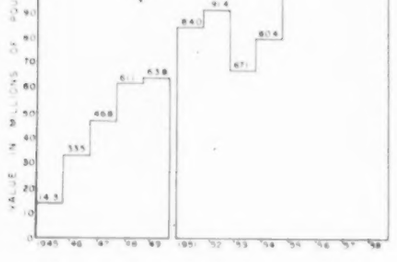
At the first general meeting of the Council of British Manufacturers of Petroleum Equipment (CBMPE), T. L. Bonstow, then honorary secretary, said that he had interested himself in getting the council started because he had been "in the oil business since 1911 . . . and long years ago I had the idea of boosting British manufacturers in supplying petroleum equipment . . . . . that has been the object I have had steadily before me."

Negotiations and "hard thinking" going back to early 1942, Mr. Bonstow recalled, had resulted in the calling together of "The British Development Co. for Petroleum Installation." It was intended as a political move by manufacturers interested in making equipment for the petroleum industry "to let the government know the available capacity in the country" with special reference to international negotiations concerned with the postwar rehabilitation of the oil industry. The current title was decided on shortly after, as being more suitable and descriptive.

The first general meeting was held, July 1943, under the chairmanship of S. T. Robson—then London manager of Head Wrightson & Co., who had taken a leading part in the prior consultation; and C. R. Sams, the first honorary treasurer, reported the membership as already numbering 93 firms. Now there are some 450 member-firms, and an information service has been opened for those interested in the industry but not qualified for membership.

This first general meeting accepted Mr. Robson's definition of CBMPE aims and objects as being "educative, publicity and propaganda type, and concerned essentially with a common broad, commercial program, taking no active part whatever in associations, trading, price fixing, quota arrangements, and the like . . ." Standardization was among the matters discussed as vitally necessary if the British petroleum equipment industry was to progress. It was felt that the concept would enable British firms to coalesce into a new and independent section of industry capable of creating an aggressive policy, so that officials concerned in postwar negotiations would have a complete picture of the scope and capabilities of this section of industry for future development.

Value of Orders for Material and Equipment Placed in the UK by Oil Companies—1945-49 Export Only; 1951-58 Domestic and Export



The council opened its own offices in November 1943, when Miss D. B. Jaques joined the staff. In 1945 she became secretary, with Mr. Bonstow assuming the title of technical adviser. He continued in this role until 1957, when he became the technical consultant, and G. C. Carr took up the appointment of technical adviser.

At the 1948 general meeting, Mr. Robson's successor as chairman—E. F. E. Howard, of Hayward Tyler & Co., a founder-member of the council—was able to claim that it had "reached its first objective," recognition and consultation by oil companies, government departments, and by others interested in the industry. He set as the next objective "closer cooperation with the petroleum industry and the furtherance of member's interest in the knowledge of petroleum equipment."

During those five years to 1948, many of the council's principal activities had been started, as the following brief details illustrate:

The "*Classified List of Equipment and Services*," one of the first activities, was started in 1943.

"*British Petroleum Equipment*"—the biennial catalog—was first published in 1947.

"*British Petroleum Equipment News*" which started as an occasional periodical in 1947 and became quarterly shortly after.

News services and technical inquiry work were also among the first activities being put in train when offices were opened.

Standardization work started early 1944 by informal technical discussions between members interested in any particular line of eqiupment; these led to joint working with the British Institution from 1945 on.

Two overseas missions were organized—to the Caribbean in 1946 and the Middle East in 1947. These led to informal discussion meetings in various centers, to the formation of regional committees, and to overseas luncheons and discussion groups.

The first five years to 1948 were indeed fruitful of good foundation work.

The third CBMPE chairman, the late Douglas Wilson (The United Steel Companies Ltd.), took office in 1951, fresh from taking part in OEEC Mission No. 57 to the USA in that year. This was followed in 1953 by OEEC Mission No. 121—the Intra-European Mission, led by Mr. Wilson—when real impetus was given to the idea of a European federation. A resolution adopted at the Third World Petroleum Congress, at The Hague in 1951, had urged that western European countries should try to establish common standards for petroleum equipment: The session at which this resolution was adopted was under Mr. Howard as chairman of the CBMPE. Thanks to French initiative, and with active help from the council in support of Mr. Wilson's special interest in the matter, the Federation of European Petroleum Equipment Manufacturers was formed in 1953 with headquarters in Paris, and with Mr. Wilson as its first president.

From the outset of his chairmanship, therefore, Mr. Wilson was able to point to "widening horizons." He wished to see the council "promoting and encouraging long-term process research in cooperation with the oil companies"; and the Chemical and Petroleum Engineering Exhibition, so successfully held in 1958, in conjunction with the British Chemical Plant Manufacturers Assn., was born during his period of office.

G. V. Sims Le Grand—Sutcliff & Gell Ltd.—took over the chairmanship in 1956, but relinquished it early in 1957 to become the council's director. During his period of office, the third overseas mission came to fruition; and the technical economic and good-will mission to Canada, under the leadership of J. M. Storey, CBE (Dewrance & Co. Ltd.), left for Canada in May 1957. Its report aroused considerable interest on both sides of the Atlantic. Mr. Storey, CBE is now vice chairman of the council.

The present chairman—G. H. Thorne (Dawnays Ltd.)—took office, July 1957, and again his period of office has been marked by yet another development in overseas activity, this time in Latin America.

Early in 1958, the president of the Board of Trade, having just returned from Mexico, asked council members to meet him to discuss the possibilities of re-establishing British-Mexican trade. He recommended the CBMPE send a fact-finding and good-will mission to Mexico speedily to follow up the good will his visit had created. A mission was formed which went to Mexico at the end of February 1958: Its members were Peter Matthews (Stewarts & Lloyds Ltd.), F. R. Newman (Newman, Hender & Co. Ltd.), and G. V. Sims.

A result of this mission was that a party of Pemex officials visited the UK during the Chemical and Petroleum Engineering Ex-

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Thomas L. Bonstow, technical consultant to CBMPE

G. C. Carr, CBMPE technical advisor

G. V. Sims, CBMPE director

hibition at Olympia in June 1958, and made it clear they were impressed by what they saw there.

Some of the points mentioned briefly above are worthy of amplification.

Equipment Exhibition—The June 1958 exhibition already mentioned, the first to be organized, was felt by all concerned to have been a success and sufficiently encouraging to be regarded as only a beginning. The joint exhibitions' committee has agreed to support the promotion of a second national exhibition. This will also be at Olympia, in London, in June 1962. A four-year period appears best from the aspects of developments within the industry, the international conference and exhibition program, and the availability of Olympia.

World Petroleum Congresses—The council has made a practice of interesting itself actively in these gatherings, and for the Fifth World Petroleum Congress in New York has taken stand No. 496 at the Petroleum Equipment Exhibition.

Standardization—One of the council's earliest, and subsequently most rewarding, activities initiated by Mr. Bonstrow was the all-out effort to draw British manufacturers' attention to the vast potential home and export market in specialized equipment for the oil industry and to the essential need for standardization and rationalization in design based on accepted American practice to insure uniformity and interchangeability of items commonly used by international oil companies.

As new firms entered the equipment field, the council grew rapidly and within a few years had up to 20 technical committees engaged on these problems. Their efforts, supported by the oil companies (later through the medium of the Oil Companies Materials Committee, now renamed the Oil Companies Materials Assn.) prompted the British Standards Institution (BSI) to form the Petroleum Equipment Industry Standards Committee. This body, with its related Petroleum Engineering Equipment (PEE) Committees, has produced some 35 standards, and at present is engaged on 17 more new and revised standards in the PEE series alone.

A recent standardization development is that BSI has requested Mr. Carr—CBMPE technical adviser—to undertake the metric conversion of all imperial measurements in the text and tables of nine existing standards for valves and fittings, a task involving many thousands of conversions.

Valuable work, not lending itself to joint standardization, has also been carried out. One example is the work of the joint committee for the study of corrosion problems, set up in 1950 at the oil companies' suggestion. Three subcommittees (each with several panels) were set up to cover: (I) corrosion by combustion gas of tube supports; (II) protective coatings for buried and submerged structures; and (III) cathodic protection of buried and submerged structures. By 1951, committees II and III had stimulated commercial developments which were considered best continued between individual users and suppliers. By this time, committee I had set on foot some valuable research, and its convenor—Dr. L. B. Pfeil, of The Mond Nickel Co.—still has in hand some studies on samples of alloy materials exposed to corrosion by the combustion of fuel oil containing vanadium pentoxide and sodium chloride.

Technical Information and Inquiries—Apart from regular council news and the periodical market information service supplements, members are supplied weekly with circulars of industry news and technical information based on published material.

The technical inquiry service has increased in scope over the years, and ranges from questions related to the "Classified List of Equipment and Services" to a wide variety concerning operational techniques, materials, and specialized plant. Apart from subscribers, the service has been made use of increasingly by public bodies, government departments, British and other oil companies, export and import agencies, and a wide range of public entities.

The "*Supplier's Guide*" surveys, inaugurated recently by Mr. Carr, are proving useful in the promotion and furtherance of the export of petroleum plant and equipment.

Council Publications—Since 1947, the combined catalog "British Petroleum Equipment" and "Classified List of Equipment and Services" has been published biennually, and copies of the latest edition—the 1959-60, containing some 790 pages of announcements from 320 members—will be available at both the World Petroleum Congress and the European Technical Congress. This catalog has come to be used throughout the petroleum industry as an invaluable guide to the wide range of British mechanical engineering equipment.

The quarterly magazine "'*British Petroleum Equipment News*," enjoys circulation similar to the other publications, and considerable importance is attached to its occasional "special language" numbers: An edition in Arabic is now in preparation.

Other Activities—Bare mention must suffice for many other CBMPE activities in London and its regional centers: The information discussion meetings at which oil-industry specialists keep members informed of particular avenues of technical interest; the "overseas" meetings at which talks are given on outstanding developments abroad; the annual dinner, where well over 1,000 members and their guests get together regularly in a social atmosphere; oil installation and inter-works visits have long been a popular activity.

From all this record, it must be clear that the foundations laid by the foresight of T. L. Bonstow and C. R. Sams in the late war years were indeed sound. The aims and objects they had in mind for the Council of British Manufacturers of Petroleum Equipment have been developed faithfully and, what is more important, expanded in keeping with the needs of a British industry whose virility has grown by leaps and bounds.

New Development: The latest CBMPE development is announced as this review goes to press. It is without doubt the most important step this body has so far taken. This is the registration of a subsidiary—British Oil Equipment Credits Ltd.—with a nominal capital of £100 in £1 shares. Its objects are stated to be to create and operate schemes to provide and/or obtain finance in connection with the sale on deferred terms to overseas purchasers of products of the UK petroleum equipment industry, for use anywhere in the world by the petroleum industry, and to obtain insurance cover for due payment by such purchasers for such products.

Chairman of the new company is E. F. E. Howard (Hayward Tyler & Co. Ltd.), and the managing director G. V. Sims (CBMPE director). Other members of the board are N. H. Birdseye (Braithwaite & Co. Engineers Ltd.); L. S. Dawson (Oil Well Engineering Co. Ltd.); Norman C. Fraser (W. J. Fraser & Co. Ltd.); J. L. Galloway (The Cape Asbestos Co. Ltd.); G. L. Hancock (David Brown Industries Ltd.); G. Henderson (Bruce Peebles & Co. Ltd.); K. M. Leach (Audley Engineering Co. Ltd.); P. A. Matthews (Stewarts & Loyds Ltd.); A. R. Miller (Motherwell Bridge & Engineering Co. Ltd.); F. R. Newman (Newman, Hender & Co. Ltd.); J. M. Storey (Dewrance & Co. Ltd.); J. H. N. Thompson (John Thompson Ltd.); G. H. Thorne (Dawnays Ltd.); Hector D. Walker (Constructors John Brown Ltd.); and E. C. Whiteley (Metropolitan-Vickers Electrical Co. Ltd.). British Oil Equipment Credits is operated from CBMPE offices, and the secretary is Miss D. B. Jaques. It is announced the company is endeavoring to arrange deferred terms for the supply of equipment for an extension to the Minatitlán refinery in Mexico. END

View of B.P. (Kent) Refinery, Isle of Grain, showing extensive offsite facilities engineered by Frasers, in joint contract with the Power Gas Corporation. Frasers also built copper chloride, solutizer and platformate splitter units at this refinery.

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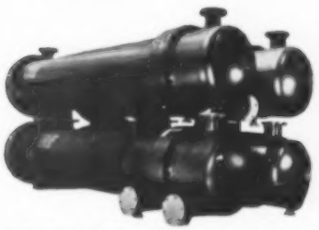
Complete plastics plant for Petrochemicals Ltd., Partington, Manchester—one of several petroleum-chemical factories engineered and constructed by Frasers in recent years.



A batch of heat-exchangers with stainless steel tube bundles fabricated by Frasers for a Middle East Refinery. Frasers' works are on Lloyds Class I list for pressure vessels and manufacture a very wide range of specialised items.

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One Hundred Years of Oil

A survey of principal developments in the USA petroleum industry during the past century

by Neil P. Hurley, S. J., and Sebastian J. Raciti
Industrial Economics Program, Fordham University, 1958.

This survey on the growth of the oil industry during the past century is a set of notes covering the developments in production, refining, transportation, and marketing of petroleum and its products. A great deal of material is encompassed in a relatively few pages, and thus the style is often abrupt. It is hoped, however, that it will serve as a storehouse of information for those who may wish to use it as supplementary matter for courses in economic history, economic geography, and industrial economics.

The work has been issued in connection with the Industrial Economics Program at Fordham University, under the general direction of William T. Hogan, SJ.

Preface

Since Edwin L. Drake drilled the first oil well recorded in this country at Titusville, Pa., in 1859, petroleum has played an important part in the growth and development of the American economy. Before Drake's discovery, machines accounted for approximately 35% of all work done in manufacturing in the United States, while the remainder was done by human and animal effort. Subsequently, petroleum made possible the development of efficient high-speed steam engines, internal-combustion engines, and other machinery which greatly reduced this arduous toil. Our use of mechanical energy has multiplied 200 times in 10 decades, and machines now acount for 99% of the total work done in this country.[1*]

Since the American oil industry now is observing its centennial anniversary, it is the purpose of this paper to highlight the important and significant events which ocurred in the industry during the past 100 years. A complete and comprehensive report of all events is not possible because a considerable expanse of time is to be covered. Thus a selection of the most important developments will be presented in chronological order and classified as far as possible according to the various operational stages within the industry. Each chapter will deal with the developments in production, refining, transportation, and marketing in a particular decade or decades.

1859-1880

Our knowledge of the existence of crude petroleum in the United States goes back beyond Drake's discovery in 1859, for history tells us that it was used by the American Indians for bartering and medicinal purposes. However, it was not until the mid-19th century that the search for a better illuminant than whale oil and tallow candles led man first to extract a crude liquid hydrocarbon from coal and shale.

Early oil activity was recorded in California in 1855, when two Mexicans scooped up black tar from pits in southern California and sold this substance to the San Fernando missions for healing and illuminating purposes.[2] Subsequently, in 1857, a primitive type refinery was operated in the same area which provided products including heavy residue which remained after the boiling off of vapors. This residue was used as a grease for ox-cart axles. Reports of oil activity existed in many other areas of the United States during this same period, but only these two incidents are mentioned as evidence that such activity did exist before 1859.

The Pennsylvania Rock Oil Co., formed by George H. Bissell and J. G. Eveleth in 1853, is generally regarded as the first petroleum company in the United States.[3] These two men recovered oil from the seepages on their land in Pennsylvania and sold their product for $1.50 per gallon. In 1855, they hired Professor Benjamin A. Silliman, Jr., for the purpose of analyzing their oil and finding more extensive uses for it. As a result of his investigations, the professor concluded that kerosine and many other products could be derived from the refinement of crude oil.

Due to the conservative attitude of the stockholders in the Pennsylvania Rock Oil Co. in regard to oil speculation, Bissell and Eveleth decided to form the Seneca Oil Co. to drill for oil near Titusville, Pa., On August 20, 1859, Edwin Laurentine Drake and "Uncle Billy" Smith, in the hire of the new company, succeeded in becoming the first men to discover oil by drilling. Within a very short time, oil speculators and wildcatters filled the Venango valley where Drake had found oil, and soon intense activity was evident in that region of Pennsylvania.

Not long after, Lewis Ross, a Cherokee Indian engaged in salt mining in Oklahoma, struck oil at the Grand Saline. His discovery paid out 10 b/d for nearly a year. As a result, there was some limited activity in oil production in the Southwest. It is estimated that total USA production in 1859 amounted to about 2,000 bbl of crude oil.[4]

During the two decades from 1860 to 1880, petroleum products were used primarily for lubrication and illumination. Those engaged in the oil business at this time were concerned mainly with the discovery, production, and refining of crude oil while other segments of the industry, such as transportation and marketing, remained in a somewhat primitive state and supplied only local needs.

Oil activity centered about the Pennsylvania region and soon spread to the neighboring states of Ohio and West Virginia. With the exception of California, the development of rich oil fields west of the Ohio River was restricted because of their great distance from the large eastern market. It was not until the areas of the Southwest were further developed, with adequate transportation arteries, that the potential of these districts warranted large-scale oil production.

Oil springs and seeps were not uncommon in Texas, and an attempt was made to find oil with a spring-pole rig as early as 1859. This first attempt failed; but, in 1866, Lynis T. Barrett successfully drilled a well in Texas. Meanwhile, rumors of oil seepages in southern California brought Professor Silliman, who had analyzed the Titusville samples in 1855, to the West Coast. In 1864, after a considerable study of the Ojai properties located near San Buena Ventura, he concluded that the 18,000 acres he had surveyed could yield a net profit of $1,365,000, if 10 wells were drilled. As a result, three companies were formed under the aegis of Tom Scott, a rich wildcatter from Pennsylvania. He organized the Philadelphia and California Petroleum Co., the California Petroleum Co., and the Pacific Coast Petroleum Co. into a syndicate which purchased territory amounting to 277,000 acres. However, only the California Petroleum Co., capitalized at $10 million in 1865, ever actively engaged in production.[5]

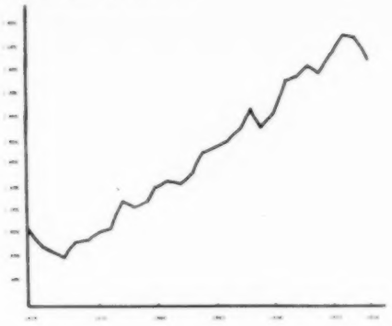
Although crude oil was available in sufficent quantities, the western market was too weak to support refining and marketing of local supplies; by 1867, eastern "coal oil" was selling in San Francisco for 54 cents less per gallon than California-processed kerosine.[6]

In the period from 1865 to 1867, the pioneer oil boom on the West Coast witnessed the formation of 70 companies capitalized at $45 million.[7] The reason for such extensive capitalization was the quantity of equipment for drilling which had to be shipped from the east to the Pacific Coast. In addition, dry holes outnumbered producing wells nine to one, and thus large initial funds were necessary.

In 1869 and 1870, two attempts were made to stabilize the existing conditions in the oil industry. The Petroleum Producer's Assn. of Pennsylvania was formed in 1869 in order to combat abuses in the industry. This organization opposed unfavorable state legislative proposals, attacked attempts at monopolization, and issued monthly statistical reports on production.[8] Further, intense competition and unfair business practices between many oil companies caused the price of refined oil products to fluctuate violently. This chronic uncertainty of the market led to the organization of The Standard Oil Co. (Ohio) on January 10, 1870, with John D. Rockefeller as president. The facilities of the new company consisted mainly of two large Cleveland

* Superscript figures refer to list of REFERENCES at the end of this article.

Annual production of crude petroleum in the United States (millions of barrels.)



refineries. This event was important because it represented a step toward horizontal integration at the refinery level and the beginning of intensive vertical integration. Within 12 years, the Standard Oil Co incorporated into its organization a large segment of the USA oil industry through its acquisition of holdings in pipeline companies, refineries, and marketing facilities.

Production Techniques and Methods: Exploration for and production of oil in the early years of the industry was far from scientific. Most prospectors and wildcatters depended upon rumors or extensive evidence of oil seepages, and drilling equipment used at this time penetrated the earth's surface at the rate of 3 ft per day. The Drake well was made by employing an old steam engine for power, a hemp rope attached to a bit, a crude wooden windlass, and a rough-hewn bailer for bringing drillings to the surface. Nevertheless, it established the validity of the concept of drilling for oil.

One of the most common techniques used for drilling during the 1860's was the spring-pole method.[9] A length of manila rope with a heavy bit tied to its end was attached to a "springy" pole which was suspended over the proposed hole. By raising one end of the pole, the bit was made to punch a hole into the ground. Sinking a shallow hole was fast and cheap, especially in the Pennsylvania area. The application of this principle became known as the cable-tool method. By manual operation, this method drilled holes 700 ft deep; but, as greater depths were sought, the bit could no longer be yanked up fast enough by hand, so steam engines were employed. The engines turned a bull wheel which rocked a beam which raised and dropped the heavy bit. This operation proved to be four times faster than manual drilling.

The pulverized material at the bottom of the hole was mixed into a slurry by periodically dumping water into the shaft. The slurry was then removed by a bailer. The steam engine was especially useful in southern California where rock formations and the anticlinal[10] nature of the earth made the manual spring pole ineffective.

Although rotary drilling was not actually employed until the 1890's, the principle behind this method was applied to a well drilled in Texas in 1866. The basis for this method is the augur, i.e., a bit which bores through geological strata by the rotation of a continuous column of steel pipe which has sections added to it as the hole deepens. The cuttings which accumulate at the bottom of the pipe or hole are displaced by forcing mud down through the hollow center of the drill pipe until the mud rises to the surface again between the casing and drill pipe. This process enables drilling to reach considerably greater depths than the spring-pole or the cable-tool method.

Another innovation was the use of "directional drilling" in 1866 by Josiah Stanford in California. Stanford dug a tunnel into the slope of a mountain and tapped an oil-sand formation through the use of directional drilling, or what may be described as a crooked hole. Although this method was sometimes misused to tap a neighbor's oil field, it was eventually employed for a better purpose, as tapping offshore reservoir beds.

Although considerable progress was made in drilling techniques, it is interesting to note that the Texas Meinsinger discovery in 1878 consisted of a well 102 ft deep which was dug by hand.[11]

Progress in drilling techniques did not alleviate the great waste which accompanied increased activity. Production methods did not allw for the control of drilling or the flow of oil. Since the principle of the "law of capture" was adhered to, waste was not only tolerated, but encouraged. According to this legal interpretation, the oil in the ground belonged to the person who was able to "capture" it by bringing it to the surface. Thus many wells were drilled in order to offset a neighbor's well and to remove the oil as quickly as possible. Consequently, the market often fluctuated between periods of glut and scarcity, and the valuable pressure needed to bring crude oil to the surface was wasted.

Refining: Samuel M. Kier is credited with building the first refinery in the United States at Pittsburgh, Pa., in 1850.[12] He constructed a still with a capacity of 5 bbl to remove the smoke and the offensive odor from petroleum so that it could be used as an illuminant. The first refinery in the Oil Creek region near Titusville was built about a mile from the Drake well shortly after 1859.

Early refineries resembled oversized tea kettles, and they eliminated impurities by boiling the crude. Th only separation process known was distillation, whereby "cuts" or fractions separated from the crude became commercially useful products. The crude was vaporized in a still, cooled, and allowed to condense into liquids from which only kerosine and lubricants were used. The yield of refined products from a barrel of crude ranged from 25% to 40% through the use of this process.

Transportation: Water travel was the main method for shipping oil and its products during this period. Artificial freshets were constructed to carry fleets of flat boats and barges down Oil Creek in the Venango valley. These barges had an average capacity of 1,000 bbl to 3,000 bbl, and were transferred at Oil City to steamboats and moved down the Allegheny River to Pittsburgh, where the oil was refined. Railroads then hauled the products of the refineries to the large market on the Atlantic seaboard. Barges were also used to transport oil in the Gulf Coast area and along the Mississippi and Ohio Rivers.

Rail transportation was also important at this time. In 1865, a flat car was able to carry two wooden tanks holding 40 bbl to 50 bbl each. Eventually, the capacity of the car was increased to 90 bbl by use of an iron tank.[13] In the mid-1870's, the horizontal tank car came into use.

The hazards of floating crude down Oil Creek to Iron City and delays caused by floods, dry periods, and ice caused teamsters to haul the crude by mule carts. In 1861, General Karns decided to build a 4-in. wooden oil line from the Tarr farm to Oil City —a distance of about six miles.[14] Realizing that this innovation might destroy their lucrative business (many teamsters earned $30 a day[15]), the teamsters tore up and burned the oil line. Thus commenced a colorful struggle between the mule cart and the pipeline.

In 1862, a 2-in. iron pipeline powered by flywheel steam engines was laid over a short distance in order to establish the principle of using pumps. Even before this experimental line could be perfected, it too was destroyed by the indignant teamsters.

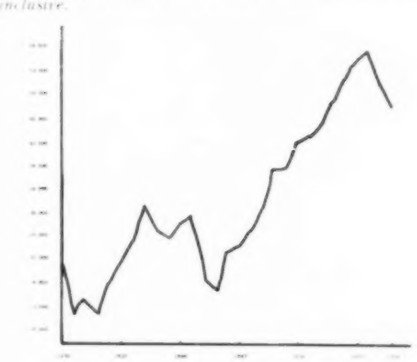
The first successful pipeline for oil was completed, October 10, 1865.[16] Made of cast iron, 2 in. in diameter, and covering a distance of about six miles, this line linked oil wells at the Miller farm to a refinery at Titusville. Leakage problems were solved by threading the pipe joints and screwing them together. Three steam-driven pumps enabled 1,900 bbl to be delivered in one day—thus replacing 300 heavy teams laboring 10 hours per day. Although this line met a familiar fate at the hands of the teamsters, opposition of the latter began to decline as the pipeline proved itself to be far more efficient and economical than mule-cart transportation.

Later, a trunk line was begun from the Pennsylvania oil region to Pittsburgh. Completed in 1874, it carried a daily average of 7,500 bbl through 60 miles of 4-in. pipe.[17] Most of the pipeline trunks and gathering lines worked on a gravity-feed principle, being sloped for short distances to obviate the need for pumping stations. Because no market warranted them, pipelines did not appear in the Gulf Coast and California areas until the 1880's. In 1879, a major pipeline extending 110 miles from Coryville, Pa., across the Allegheny Mountains to Williamsport, Pa., was completed.

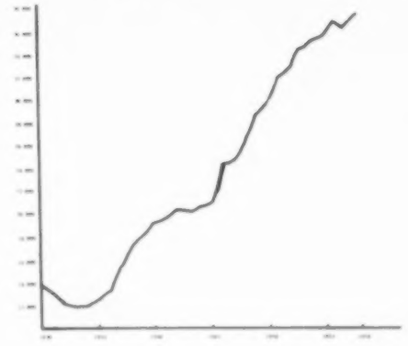
Marketing: As previously stated, petroleum was used primarily for medicinal purposes, illumination, and lubrication. Petroleum products were distributed by peddlers and through local hardware and grocery stores, while door-to-door deliveries were made by means of horse-drawn wagons. Later, urban areas were served in a fashion not unlike our modern milk industry; kerosine was delivered in containers by oil companies and the "empties" were picked up. Rural storekeepers and small-scale retailers, such as the grocery and hardware stores, sold kerosine in wooden barrels. In 1878, oil was sold as a lubricant in central Texas at 50 cents a gallon, while a 4-oz. bottle for medicinal purposes cost 25 cents.[18]

Summary: In general, the period was one of slowly increasing activity for the Southwest and Pacific Coast, but of constant growth for the states of Pennsylvania, Ohio, and West Virginia. The short-run view of wasteful drilling and extraction predominated because of the competitive nature

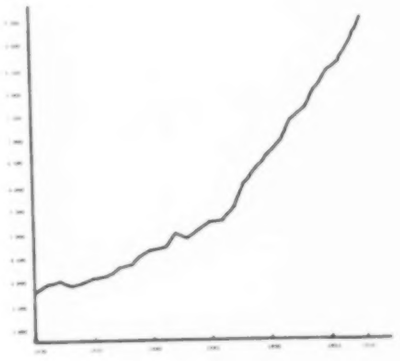
Total wells drilled in the United States 1930 to 1958 inclusive.



Proved reserves of petroleum in the United States 1930 to 1958 (millions of barrels).



Oil consumption in the United States (thousands of barrels daily).



and speculative appeal of the oil industry in these years. Except for the attempts made by The Standard Oil Co., specialization—and not integration—characterized this era. Drilling, producing, barrel making, refining, etc., were not to be integrated until later.

TABLE 1

USA CRUDE-OIL PRODUCTION, 1859-1880

(Thousands of Barrels)

1859	2	1870	5,261
1860	500	1871	5,205
1861	2,114	1872	6,293
1862	3,057	1873	9,894
1863	2,611	1874	10,927
1864	2,116	1875	8,788
1865	2,498	1876	9,133
1866	3,598	1877	13,350
1867	3,347	1878	15,397
1868	3,646	1879	19,914
1869	4,215	1880	26,286

Source: *Petroleum Facts and Figures*, New York, American Petroleum Institute, 1950, p. 148-9

1880-1900

The emergence of the Rockefeller-dominated Standard Oil Co. was the most significant event of this decade. Through Rockefeller's efforts, Standard became the major oil company in the country, and the giant corporate form of an integrated business enterprise was established. This form of enterprise was necessary to finance and govern large-scale operations ranging from exploration to marketing. Another important development was the continued growth and competition of the Pacific Coast and Southwest oil fields along with the eastern oil industry.

Production Areas and Companies: Early geological surveys in Kansas and Texas seemed to consider coal deposits more valuable than the potential oil pools.[19] However, after the discovery of the Paola field in Kansas, over a million acres of land were leased to speculators and wildcatters. One company, owned by John Fertig, purchased 500,000 acres of leases and drilled 136 wells. Production of crude petroleum in Kansas increased to 74,000 bbl in 1900 from 50 bbl in 1889. The peak year for Kansas in this decade was reached in 1896, with the production of 113,571 bbl.[20]

An important development occurred at this time in Texas. On June 9, 1894, three water prospectors inadvertently struck oil at Corsicana after they had drilled to a depth of 1,027 ft.[21] The pool was large, and daily production at Corsicana rose to 65,000 bbl in 1897 from 1,500 bbl in 1896.[22] Soon companies began to construct and provide storage, refining, and marketing facilities for the area.

The rapid growth of the industry—not only at Corsicana, but throughout Texas—may be attested to by the fact that the 1898 production figure of 546,000 bbl represented an increase of 480,000 bbl over the previous year.[23]

The oil industry reached its zenith in West Virginia with the production of 16 million barrels of oil in 1900. This figure represented a 100% growth in output over 1880 for the state.[24] Production also increased in Indiana. In 1890, there were 444 oil wells in the Lima fields; and in 1900, with the addition of more wells, five million barrels of oil were produced there.[25] During this same period a little oil activity existed in Kentucky and Missouri.

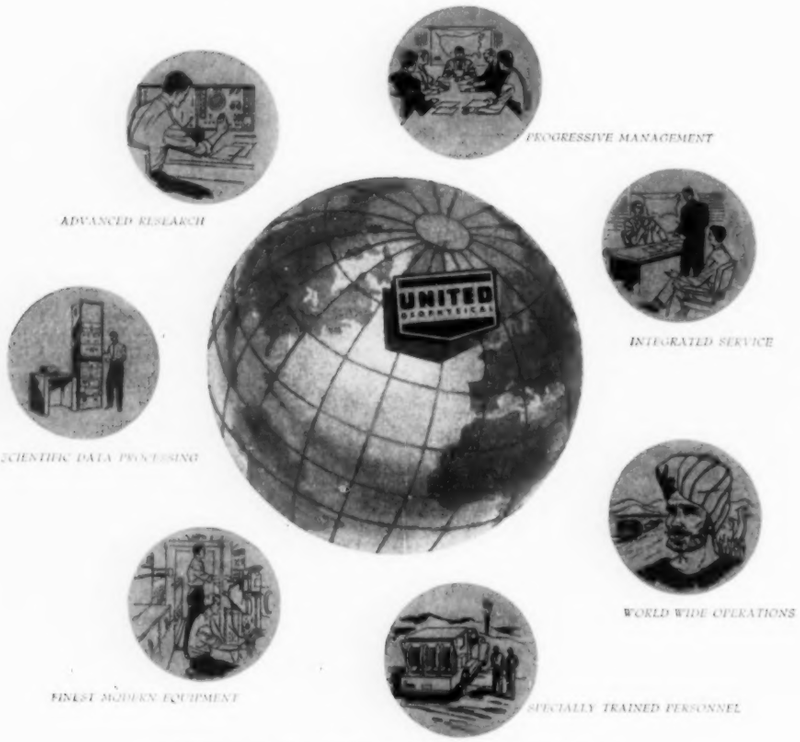
The 40,000 bbl of oil which California produced in 1880—taken mainly from the Ventura, Los Angeles, and Santa Barbara regions—rapidly increased to over 20 million barrels shortly after the turn of the century.[26] One of the main reasons for this tremendous growth was the formation of the Union Oil Co. of California in 1890. In 1882, Lyman Stewart migrated to California from Pennsylvania where he had accumulated a sizeable fortune. With additional funds supplied by Wallace Hardison, the two men began to explore for oil. In 1888, they brought in the first gusher in California, which flowed at the rate of 800 bbl to 900 bbl daily.[27] On Oct. 17, 1890, they incorporated the Union Oil Co. through a merger of four smaller companies. Union had no real competitor in California until another group formed the United Petroleum Co. in 1899.

Without question, the formation of The Standard Oil Trust on January 2, 1882, was the most significan development of this period. The trust agreement was signed by 41 companies, and it brought together properties valued at $70 million. By this agreement, the Ohio Standard Oil Co. was divested of its out-of-state holdings in order to avoid heavy tax burdens.[28] This was done because of a suit pending in Pennsylvania whereby an out-of-state company might be taxed not only on its physical properties within the state, but also upon its entire capital stock and dividends. If the test suit were upheld, it was feared other states would take similar action. Thus, to avoid long litigation and the possibility of double taxation, the trust agreement created a special corporation to hold Standard Oil properties in each state. The management of this alliance was conducted from the city of New York. As a result, two very important companies were incorporated at this time: Standard Oil of New Jersey and Standard Oil of New York.

With a capitalization of $3 million, the New Jersey company was limited by its certificate of incorporation to the processing, packaging, and sale of products from petroleum and the manufacture of acids. The New York company began with a $5 million capitalization. Its main function was to serve as the principal instrument for export sales; as the chief banking unit for the associated companies; and as the major supplier of staff personnel for the centralized management of the organization.[29]

The committee system was an outgrowth of the new corporate setup. A number of committees (e.g., Executive Committee, Export Trade Committee, etc.), sought to provide expert advice so that the activity of all the companies could be coordinated, standardized, and integrated. This method of managing set the pattern for future large USA industries.

Rockefeller's alliance came about as a reaction to the instability and unpredictability of the oil industry in the 1870's. By horizontal integration at the refining level, he hoped to gain advantage over the railroads in regard to rebates and drawbacks.[30] Vertical integration—including the acquisition of crude-



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oil gatherings operations, pipelines, and bulk plants —was deemed necessary to exploit the domestic and foreign market on a large scale.

In 1899, Standard Oil of New Jersey became the parent company of the group due to a court dictum of 1892 which barred the Ohio company from participating in the trust. By this time, Standard's annual domestic sales of kerosine were over 11 million barrels and domestic sales of naphtha and gasoline were over 3¼ million barrels.[31]

Production Techniques and Methods: Drilling and exploring techniques remained largely unscientific during this period, but several notable achievements were made. In 1899, the Union Oil Co. employed Frank F. Hill, who was later credited with the idea of cementing oil wells to keep out water.[32] Up to this time, drillers had used shavings, chopped rope, burlap sacks, and other materials to try to close up the space between the casing and the walls of the holes to keep out water. Through the process of cementing walls, drillers were able to reach greater depths and to double the yield from the field.

The rotary-drill method increased in popularity over the cable-tool method, and it was especially useful in California and the Southwest where deep wells were necessary. Because cable-tool drilling was mainly employed in drilling shallow wells in hard-rock formation, it was more popular in the eastern oil regions of the country.

Although wooden derricks were conventional in this period, steel derricks which could be dismantled and moved were not known in 1892.[33] Moreover, most rigs were powered by steam engines 20-hp to 30-hp capacity.

Refining: The Standard Oil Co. (Indiana) embarked upon a wide-scale program for using the bad-smelling sulfur-laden oil which it had discovered in the Lima-Indiana territories and referred to as "sour" crude. In 1899, the company built a $5 million refinery at Whiting, Ind., where the Frash process of vaporizing sulfuric oil was utilized. As a result of this achievement, chemistry began to play an important role in the oil industry.

The Whiting refinery was the largest built to that date, containing 80 crude stills with a daily capacity of 36,000 bbl.[34] Working at normal capacity, the Whiting refinery was able to process one-tenth of the total production of crude produced in the United States in 1890. It should be noted that gasoline had no widespread commercial use yet, and that kerosine was still the main product of the refineries.

Transportation: In the era of The Standard Oil Co.'s greatest expansion, rail freight differentials, with rebates and drawbacks, served as a vital competitive weapon. For example, the company's construction of the Whiting refinery and a pipeline from the Ohio and Pennsylvania fields to Chicago constituted a serious bid for the markets of the West Coast. Since they were 600 miles nearer to this market than other eastern or midwestern competitors, Standard was able to command a lower freight rate and rebates. Oil was shipped to the West in "box tank cars" which contained two square tanks with a capacity of 2,500 gallons per tank.

Pipelines grew in importance as a means for conveying oil from the fields to the refineries, and from refineries to the markets. Most of the lines, laid before 1900, were 4 in. to 8 in. in diameter. Water transportation remained the least expensive means of conveyance. An improvement in this manner of shipping occurred in 1895 with the innovation of steel barges, which replaced the regular iron barges used up to this time. These new barges were able to carry eight tanks with a capacity of 1,000 bbl each. Steam tankers also began to make their appearance at about this time.

Marketing: Oil as a fuel became more important in the years from 1880 to 1900. Oil burners were proved by Standard's marketing personnel to be economical for use in steel, brass, glass, brick, and the wagon-manufacturing industries.[35] Union Oil Co. also embarked upon a vigorous sales campaign, and was able to convince many steamship companies and corporations to convert to oil.[36]

Among the many other uses found for oil by-products during the 1890's were: naphtha for heating; benzine for paints and varnishes; distillates for cooking and heating stoves; gas for engines; light fuel oils for lubrication; and heavy residual oils for asphalt and paving materials.[37]

The Standard Oil Co. employed local draymen to deliver the products of petroleum. Tank wagons supplied by the company were coffin-shaped boxes lined with metal. Bulk plants were usually situated at 12-mile intervals so that a team of horses could reach the plant for new supplies within a day. Marketing in the West remained somewhat primitive, with methods such as 24-mule teams still being utilized.

Summary: The period from 1880 to 1900 witnessed several important developments in the American oil industry. The emergence of the Standard Oil Trust foreshadowed the coming age of industrial giants. The growth of the West and the Southwest as oil-producing areas presaged the future importance of those regions. Improved refining and increased uses for petroleum likewise indicated the role that chemistry would play in providing more and better byproducts from crude oil.

TABLE II
USA CRUDE-OIL PRODUCTION, 1880-1900
(Thousands of Barrels)

1880	26,286	1891	54,293
1881	27,661	1892	50,515
1882	30,350	1893	48,431
1883	23,450	1894	49,344
1884	24,218	1895	52,892
1885	21,859	1896	60,960
1886	28,065	1897	60,476
1887	28,283	1890	55,364
1888	27,612	1899	57,071
1889	35,164	1900	63,621
1890	45,824		

Source: *Petroleum Facts and Figures*, New York, API, 1950, p. 148

1900-1910

The decade from 1900 to 1910 is singularly important because it represents the beginning of the fuel age. Although the automobile was still in the experimental stage and considered by many to be only a novelty, its steady growth during this period resulted in a transition from the "Kerosine Age" to the "Gasoline Age." At the same time, significant new discoveries were made in the southwestern part of the country. With the demand for oil thus stimulated, new companies arose to challenge the Standard Oil monopoly.

Production Areas and Companies: The new age of petroleum began on January 10, 1901, with the greatest oil gusher this country had found up to that time. On a hillock called Spindletop (outside Beaumont, Texas), as the drill pipe reached 1,000 ft below the surface, gas and heavy oil spouted 200 ft into the air. This first well, named Lucas No. 1, in honor of its driller Anthony Lucas, flowed at the astonishing rate of 75,000 b/d to 100,000 b/d.[38] Before Spindletop, most of America's production came from the East; yet this one well alone was able to produce as much oil as 37,000 eastern wells combined. By 1902, Spindletop's 138 wells were able to match the production of the rest of the world.

With the emergence of Texas and the Southwest as wealthy oil regions, the predominant position of The Standard Oil Co. in oil production began to decline. Prior to 1901, this company controlled 83% of the nation's total oil production. However, its activities were limited in Texas for several reasons.[39] First of all, the legal climate was unfavorable, for the stringent antitrust laws of Texas had already attacked the Waters-Pierce Co., a Standard subsidiary. Second, due to the great discovery in Texas, other states in the area looked equally attractive to the company. The MidContinent fields proved that the crude from Oklahoma and Kansas were not only richer in kerosine and gasoline yield, but that the total flow from these regions was also steadier and greater than that of Texas.

Desiring to consolidate its position in California, The Standard Oil Co. of New Jersey purchased the Pacific Coast Co. Standard's influence in this area was significant, for it entered the market as a large purchaser of oil; constructed pipelines, storage tanks, refineries, and markets, to achieve an integrated operation. Consequently, it spurred local companies to a more rapid development in order to maintain their position in the market. The three major companies competing in California were: Standard Oil of New Jersey, Union Oil, and the Associated Oil Co.

One of the companies which grew to rival Standard Oil was formed because Anthony Lucas lacked the financial resources necessary to continue drilling the salt domes in the Louisiana and Texas area. In order to continue his exploration there, Lucas sought additional funds from James M. Guffey and John H. Galey of Pittsburgh. In May of 1901, Andrew W. Mellon and Richard B. Mellon, partners in a Pittsburgh banking house, agreed to help organize the J. M. Guffy Petroleum Co., with a capitalization of $15 million.[40] Later to be known as the Gulf Oil Corp., its properties included one million acres of oil leases in Texas and Louisiana; eight wells; 16 miles of pipelines; 100 tank cars; and 375 acres of land around Port Arthur.[41] On November 10, 1901, the Gulf Refining Co. of Texas was formed to take care of refining and sales. Its capitalization amounted to $750,000.[42]

Another important company, founded in 1902, was the Texas Fuel Co., later to be known as The Texas Co. This concern was headed by J. S. Cullinan, and had authorized capital of $750,000.[43] John W. Gates became a large shareholder by the time operations were begun at Sour Lake, Texas.

Sun Oil Co., with oil operations in the Middle Atlantic states and the Midwest during the 1890's entered the Texas activity after the discovery of Spindletop. In 1904, it purchased the holdings of the Lone Star and Crescent Oil Co. Eventually, the company was able to send its oil to Port Arthur by competitor's pipelines and from there to Philadelphia.[44] Thus another company challenged the supremacy of The Standard Oil Co.

As mentioned previously, other areas in the Southwest also grew in importance during this decade. In June 1901, a gusher at Red Fork, Okla., attracted great interest, and soon led to the leasing of Indian lands by the Department of the Interior.[45] By far, however, the most important discovery in Oklahoma occurred in 1904 at Glenn pool. Here The Standard Oil Co. was active through its subsidiary, the Praire Oil and Gas Co.

Glenn pool oil had a paraffin base which made it high-grade and, because it was derived from relatively shallow wells, drilling costs remained comparatively moderate. However, a temporary declining market and oil speculation presented difficulties in finding outlets for the new oil. Since the Praire Oil and Gas Co. was the principal purchaser of oil, public opinion caused antitrust proceedings against that company.

The Texas Co. and the Gulf Refining Co. also expanded activities in Oklahoma. As of September 1, 1907, the annual takings of these two companies and The Standard Oil Co. amounted to 27,050,000 bbl of Glenn pool oil. At this rate, the yearly production for the pool has been estimated at 40,500,000 bbl.[46]

Kansas oil discoveries added to the increased supply of oil in the nation. Activity in this state was divided into areas by The Standard Oil Co.: the South Neodesha region and the North Neodesha region. Kansas produced 77,714 bbl of crude in 1900, and by 1903 it reached 923,214 bbl yearly.[47] The "sweet" oil of Kansas and Oklahoma had its influence felt as far as Chicago, where it soon displaced the "sour" Lima crude of Indiana as the basic stock for the Whiting refinery.

Caddo Parish in northwestern Louisiana was the scene of a discovery in 1906 when a field was found which yielded both oil and gas. By 1909, it produced 1,028,818 bbl of oil, and in 1910 this figure jumped to 5,090,793 bbl.[48]

Although its output remained below one million barrels during this period, attention was focused on Wyoming with the discovery of its first well at Salt Creek dome in 1908.

Production Techniques and Methods: The careful analysis of faults, dips, and surface structures which indicated the location of a possible oil field became more important for firms with large investments at stake. Thus progress was made toward more scientific exploration and drilling methods during this decade. Chunks of earth from prospective areas were studied under microscopes to determine if that area contained sand, clay, shale, limestone, or other structures. Other evidence studied included fossils, wood fragments, and vegetation. The study of geophysical evidence to determine potential oil-bearing lands did much to remove some of the speculation which had played so great a part in the early years of the oil industry.

The use of a fishtail rotary bit to cut through rock formations enabled drilling to reach depths of 2,000 ft, and in 1909 the two-cone rotary bit allowed for an even deeper penetration of hard-rock structures.

Another important innovation was the use of mud as a preventive against cave-ins and for the removal of cuttings by flotation. By 1910, many of

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the wooden drilling rigs had been replaced by modern derricks made of steel.

Refining: Although no significant developments occurred in the refining process at this time, progress was made in quality control of petroleum and market research. For example, especially designed stills were used by the Gulf Refining Co. in order to desulfurize Texas crude and thereby make it acceptable to the British navy as a fuel.[48]

Refineries grew in number and soon dotted the oil regions of the Midwest, Southwest and the West Coast. Companies sought locations which would be economically preferable, but proximity to producing wells was not the primary factor considered. Transportation costs on finished products, as well as costs of purchased supplies, were equally important considerations. Another important factor was the location of the market; hence a refinery was often situated close to a source of oil and close to water and rail transportation. Refineries were also located in areas where demand was high. Standard of Indiana built a refinery in St. Louis in order to reach a highly industrialized and rich agricultural market. Thus, competition in regard to the strategic location of refineries and the special treatment of crude through chemistry became a feature of the industry at this time.

Transportation: The discovery of substantial oil reserves in Texas, Oklahoma, and other Southwestern areas resulted in the need for more transportation facilities. By January 1902, three pipelines were completed from Beaumont to Port Arthur, a distance of 19 miles. Other lines connecting Beaumont, Sabine, Galveston, New Orleans, Houston, and many other towns along the Texas Gulf were laid. Storage facilities were also constructed near the oil fields and pipeline terminals.

In California, pipelines were built from the lower part of the state, where production was heaviest, to the northern part where consumption was greatest. Hot water was mixed with the heavy oil, which contained a high asphalt base, in order to make it flow more freely. Another method used to keep the petroleum flowing was the rifled pipeline which contained spiral borings. This internal twist provided an impetus to the heavy fluid and kept it moving forward.[50]

In 1909, the Independent Oil Producers Agency organized a transportation company to rush the construction of an 8-in. pipeline in California. As a result, 240 miles of pipe, 15 pumping stations, steel tankage for 27 million barrels of oil, and better dock facilities were added to the West Coast.

Although the use of railroads, tankers, and barges also increased during this period, the significant growth belonged to the pipelines.

Marketing: The use of gasoline for automobiles grew rapidly from 1900 to 1910 as auto production increased enormously and total vehicle registration rose to 469,000 in 1910 from 8,000 in 1900[51]. Of the three possible means of propulsion used in autos—the steam engine, the electric motor, and the gasoline engine—the latter proved to be the most efficient and practical. Thus the era of fuel gas was ushered in, and companies began to concentrate on this important market. At the same time, demand for other petroleum products increased, as asphalt for roads and roofing purposes, oil for heating and generating steam, lubricating oils, greases, etc., assumed a greater role in our economic development. Morover, fuel oil was custom-made to fit the exact specifications of factories, railroads, steamships, and warships, both here and abroad.

Overproduction resulting from the discovery of oil in Texas and nearby regions brought about a major sales program on the part of the oil companies. Efforts were made to convince the public that certain types of oil were better suited for their individual needs. Thus, as the demand for oil products grew, the effort required to sell these products also acquired more importance.

Summary: The period from 1900 to 1910 provided for several significant transitions in the oil industry. It signaled the increasing importance of the West and Southwest, while the eastern oil-producing areas began to lose their positions of dominance. The greater use of the automobile provided a shift from kerosine to gasoline as the basic product of petroleum. In addition, the formation of more companies provided The Standard Oil Co. with more competition, and brought about a change in the structure of the industry.

Another interesting development of the period was the formation of the National Petroleum Assn., which included all petroleum refiners outside of The Standard Oil group. Their chief object in uniting was "the necessity of mutual aid to avoid extermination."[52] This, too, points up the movement against monopolization in this decade.

TABLE III
USA CRUDE PRODUCTION, 1900-1910
(Thousands of Barrels)

1900	63,621	1906	126,494
1901	69,389	1907	166,095
1902	88,767	1908	178,527
1903	100,461	1909	183,171
1904	117,081	1910	209,557
1905	134,717		

Source: *Petroleum Facts and Figures*. New York, API, 1950, p. 147-8

1910-1920

The development of the automobile assembly line in 1913 at Ford's plant ushered in the mass-production era in that industry. This, in turn, pushed the demand for gasoline in the 1910-20 decade to a new high.

The growth of the auto industry was spectacular, as can be seen from the increase in registration during the decade. In 1910, 468,500 motor vehicles were registered; by 1915, the number had risen to 2,490,932; and in 1920, the total was 9,239,161.[53]

The increased production of automobiles greatly stimulated the need for a low-priced fuel which could be produced in large quantities. The nature of the internal-combustion engine was such that it required a fuel which would evaporate at a relatively low temperature, with a high heat value, and which would burn without objectionable residues and odor. Benzol, Toluol, and alcohol were all seriously considered, but none compared with gasoline from the standpoint of cost and performance.

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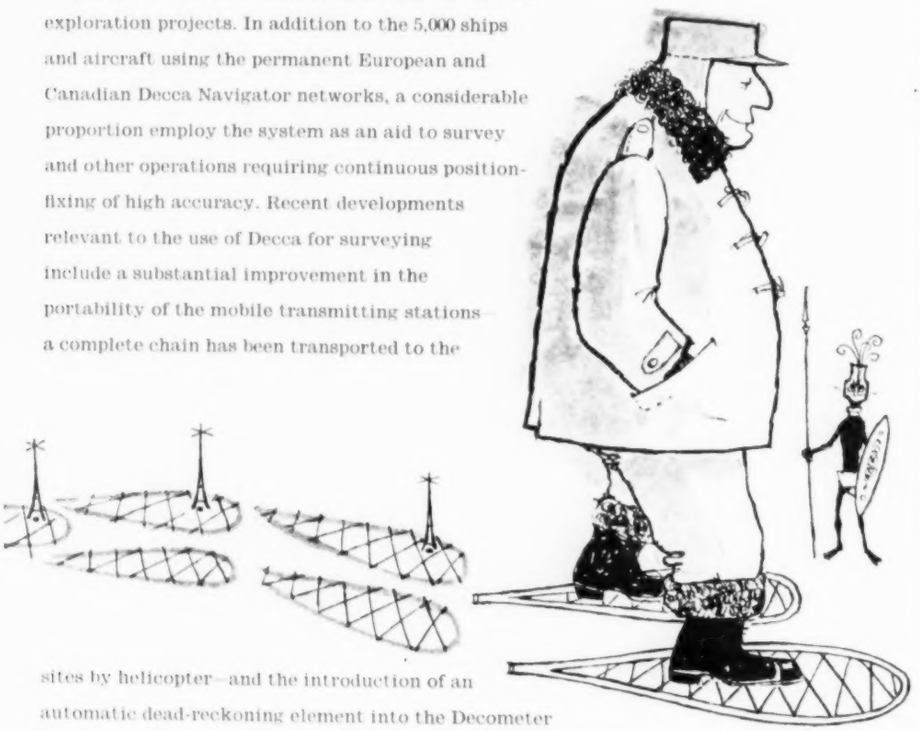

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During this same period, the World War I placed added burdens upon the oil industry. Both navies and merchant marines converted their ships to oil from coal. In addition, large amounts of oil were required for airplanes, railroads, and industrial machines.

This shortage was alleviated in part by new discoveries, many of which were in the Southwest.

Oklahoma continued to be an important oil-producing state with the development of the Cushing field in 1912. From an initial production of 11,000 b/d, the field was able to achieve a peak of 333,000 b/d by April 1915.[54] By the end of 1919, this same field covered an area of approximately 32 square miles and had a cumulative production of 236 million barrels of crude. The Healdton field, discovered in Oklahoma in 1913, also added greatly to Oklahoma's stature as an oil-producing state. It vied with California for leadership among the states until 1915, when it became the undisputed leader.

Many new major fields were found during this period. Some of the more significant ones, according to states, were: *Texas*—Ranger County, Goose Creek, Hull, Iowa Park, and Westbrook; *Oklahoma*—Cushing, Healdton, Blackwell, and Garber; *California*—Kern River, Coalinga, Sunset-Midway, Lakeview, and San Joaquin Valley; *Kansas*—Eldorado, Augusta, Florence, and Peabody; *Wyoming*—Lakeview.[55]

Another highly significant development of the decade was the dissolution of The Standard Oil Co. Attacks and allegations against John D. Rockefeller and his company mounted from 1900 to 1911. In 1907, the Interstate Commerce Commission charged the company's pipelines were failing to conduct themselves as common carriers; that the company was accepting railroad rebates, had set up "bogus" marketing companies, and generally was pursuing a policy of local price-cutting.[56]

Shortly thereafter, antitrust suits against subsidiaries of The Standard Oil Co. occurred in Missouri, Texas, Kansas, and Tennessee. In the dissolution suit decision in St. Louis on November 20, 1907, it was held that seven representatives of Jersey Standard and 37 subsidiary corporations had entered into an illegal conspiracy in restraint of trade, and had also secured an illegal monopoly over much of the interstate and international commerce in petroleum.[57] In 1911, the US Supreme Court agreed that the facts in the case indicated both intent and actual achievement of monopoly and restraint of trade. According to the dissolution decree, 33 of the original 37 subsidiaries were to be separated from the parent company. Only one member of the combination was left fully integrated—Standard of California. New York Standard, Vacuum Oil, Indiana Standard, Atlantic Refining, and Ohio Standard possessed manufacturing and marketing facilities, but not production resources.[58] Jersey Standard retained four producing companies, pipeline properties in five states, foreign holdings, and a market area which ranged from the East down to Louisiana and Tennessee.[59]

One great result of this dissolution was the immediate formation of 33 new companies all competing among themselves and with their former parent. As was mentioned earlier, almost all of these companies lacked an integrated operation. Thus, for example, Indiana Standard was obliged to purchase oil leases in Kansas and elsewhere in order to obtain oil-production properties. Consequently, most of the former members of the old Standard Oil Co. actively pursued a policy of vertical integration. Even Jersey Standard, which lacked transportation facilities and a national market, began a drive toward forward and backward vertical integration. In 1917, it purchased a majority interest in the Humble Oil & Refining Co., which was capitalized at $4 million.[60] This purchase enabled the Jersey company once again to enter the lucrative production business in Texas.

Integration activities were not confined only to the former members of the Standard alliance. Similar activity occurred in The Texas Co. and the Gulf Production Co. Hence, the intensive growth of competition during the decade 1910 to 1920 was a very significant development for the oil industry.

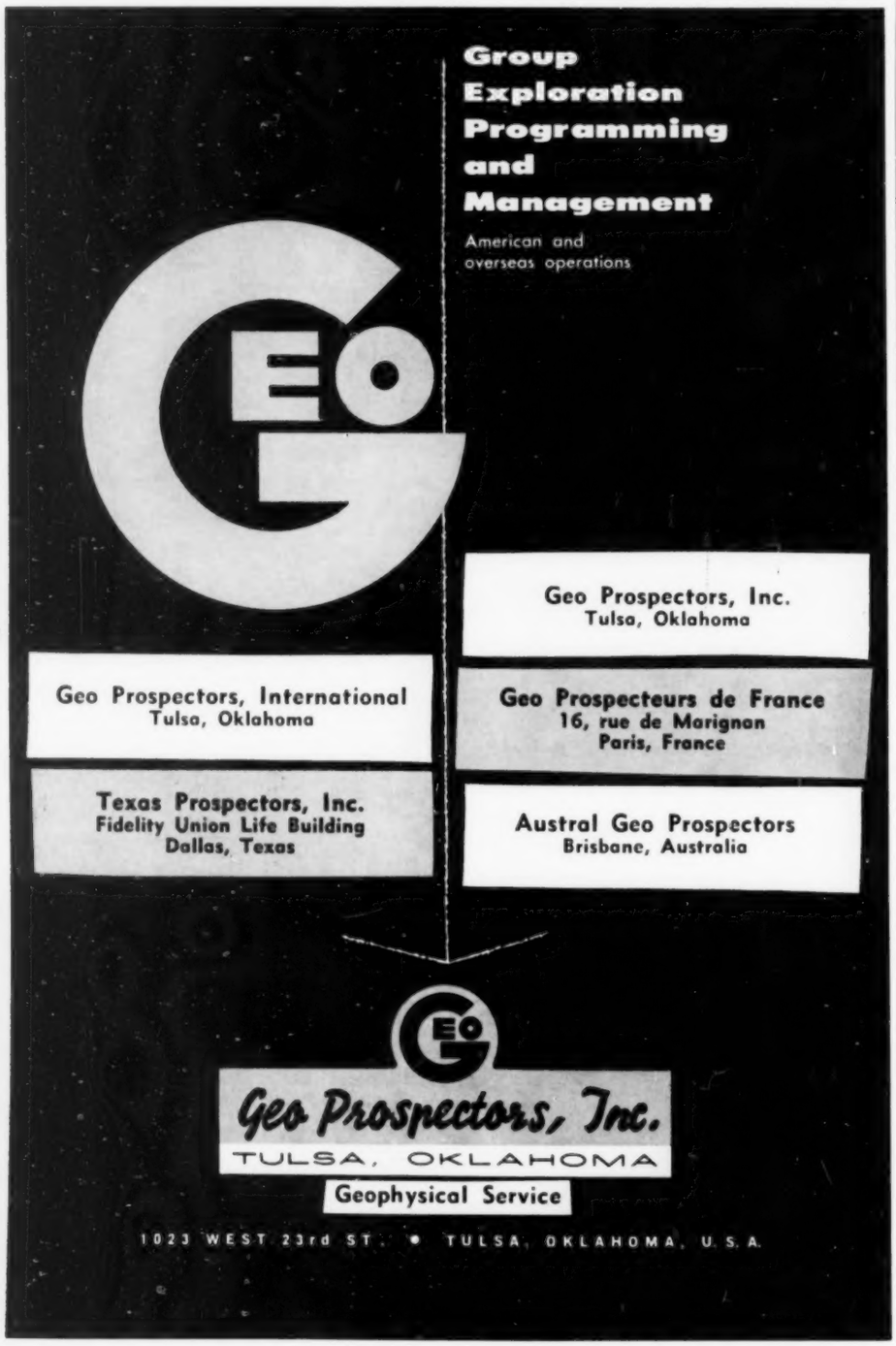
Production Techniques and Methods: World War I helped to introduce new technological developments and methods for the exploration and discovery of new oil. One such development was aerial photography whereby photos taken at altitudes of several thousand feet enabled geologists to determine subsurface geological formations from the presence of upthrusts in the rock, seepages, and outcroppings.[61]

Another new exploration method devised at this time, but not used extensively until the next decade, was the seismic or geophysical survey. Both Germans and Americans had used seismic instruments for measuring sound waves set in motion by hidden artillery in enemy territory. This principle was applied to the oil industry.

An important development in the actual drilling process was the use of diamond cutting bits. Depths of almost 3,000 ft were achieved when this bit was attached to a rotary drill.[62]

The rapid and wasteful development which accompanied the discovery of any new fields induced Oklahoma to adopt a statute in 1915 which prorated the production of oil. The necessity for conservation arose from the application of the legal principle of the "law of capture." In an analogy to game laws, American and Canadian courts decreed that whatever the landowner is able to withdraw from a common reservoir belongs to him—irrespective of the effect upon his neighbor's share in the same pool. Naturally, the only defense for the neighbor is to do likewise. This fact, coupled with the legal implications of leasing, created a necessity to exhaust proven lands as quickly as possible lest the pressure drop in the field reduce its output.[63] Under the "rule of capture," each operator had to protect against a forfeiture of his lease on the grounds that he had neglected the lessor's interest. Consequently, a juridical-economic incentive for the rapid exploration of oil lands existed. "Open-flow" production was the normal way of operating before conservation methods were enforced.

In 1915, Oklahoma invoked voluntary proration agreements whereby each operator in a field was allowed to produce only a stipulated proportion of the oil which his wells were capable of producing. The constitution of the state of Texas was amended in 1917 to permit the enactment of conservation



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legislation. Two years later, Texas passed a conservation act which defined and prohibited the waste of oil and gas and conferred regulatory power upon the Texas Railroad Commission. Shortly thereafter, the commission adopted rules and regulations pertaining to the spacing, drilling, cementing, and operation of oil and gas wells.

Another innovation at this time was the use of the "gas lift" for increasing output. Because early production and drilling methods had encouraged the waste of valuable pressure which was needed to drive the crude to the surface as little as 10% of the oil in certain reservoirs was extracted. Since the gas or water pressure was dissipated, the oil could no longer rise on its own. To remedy this, gas was pumped into a hole under pressure between the casing and tubing, and thus forced the crude up through the tubing.[66]

The gas-lift method of secondary recovery should not be confused with the use of a gas or water drive whereby pressure is brought upon certain oil wells in order to drive the crude to other wells.[66] This innovation occurred in a later period.

Refining: One of the most serious problems facing the oil industry in 1910 was the rapidly growing demand for gasoline caused by the increasing number of automobiles and the greater use of kerosine for lighting and cooking. Crude-oil production failed to keep pace with this demand, and consumers were faced with inadequate supplies and higher prices. As a result, various attempts were made to build automobile engines which would run on different fuels, but none was successful. Efforts were made to increase the gasoline yield from crude with known methods, but the best ratio attained was a yield of 15% to 18%.

The problem became critical as the price of gasoline rose to 17 cents per gallon in January 1913 from 9½ cents in October 1911.[66] In Europe, motorists often paid as much as a dollar per gallon.

To meet this situation, Dr. William M. Burton and his associates at Indiana Standard had been engaged in devising a method of refinement which would increase the gasoline yield from crude. Finally, on January 7, 1913, a patent was issued to the company for the process which took the name of its developer. The Burton process of thermal cracking represented a major technical achievement for the oil industry, and undoubtedly is one of the most important and significant events in the history of petroleum.

The development of the Burton proces had a profound effect upon the petroleum industry. An immediate result was the increase in supply of gasoline which relieved the shortage. In addition, auto sales were stimulated and the price of gasoline was kept from increasing due to any scarcity in supply. Cracked gasoline also had a much higher antiknock value; and this not only meant smoother operation for automobile engineers, but led to the development of higher-compression automobile engines.

Perhaps the greatest contribution of the new process was its conservation of crude-oil resources in the United States. For example, from 1913 to 1928 about 200 million barrels of gasoline were refined in Burton stills. Had this amount been produced by the older method of distillation, about one billion extra barrels of crude would have been required.[67]

It is significant that, at about this same time, a German, Friedrick Bergius, discovered the process of liquefying coal and applying hydrogen under pressure to the resultant synthetically produced liquid. In this way, heavy oils were converted almost completely into gas. However, the process, later called "hydrogenation," was not commercially exploited until 1926, when Jersey Standard acquired the rights to it.

Another development was the use of vertical stills or fractionating towers. However, the refining process still remained essentially a batch process.

Of great importance during this decade was the beginning of the petrochemical industry. Petrochemicals are chemical elements and compounds which are recovered directly or indirectly from petroleum or natural-gas fractions; ethylene and propylene were two such petrochemicals produced from waste refinery gases. Jersey Standard produced alcohols from petroleum fractions as early as 1919.

Since the many advances made in refining permitted greater product differentiation and thus a better adaptation to customer needs, it is easy to understand why refining became a major tool of competition.

With the growth of pipelines, refineries were able to locate near densely populated areas. Major refineries were located at Bayonne, N. J., Philadelphia, and Kansas City, Mo.; and, by 1915, Kansas and Oklahoma alone had 55 refineries processing 75,000 b/d.[68] From 1914 to 1919, the total number of domestic refineries increased to 366 from 176.[69]

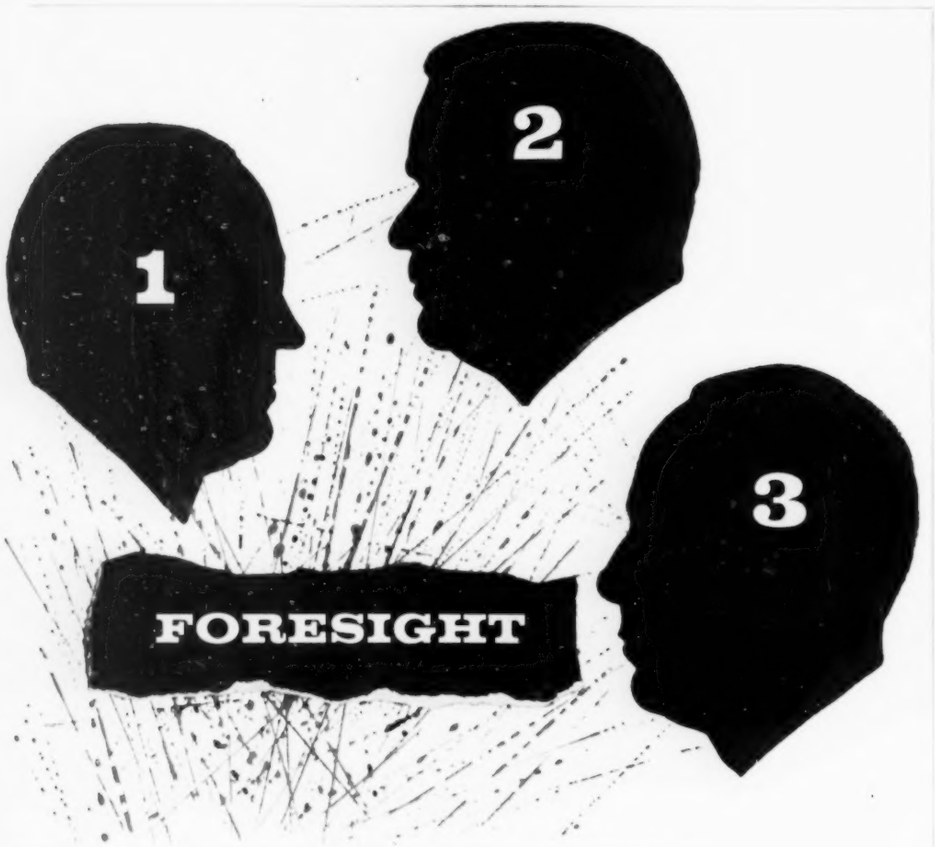
Transportation: Railroads were still helping to carry oil from producers to refiner and wholesaler, but the high cost of this service made tankers and pipelines more important. Activity with respect to the ownership and operation of crude-oil trunk lines and product pipelines led to vertical integration in the oil industry so that, by the end of 1914, the trunk-line mileage of five large interstate companies amounted to 4,320 miles.[70]

In 1914, pipelines engaged in interstate commerce were deemed to be common carriers. This meant that they were not subject to the regulations of the Interstate Commerce Commission, and that they could not refuse to carry their competitors' oil.

In order to overcome the shortage of labor due to the war, a ditching machine was used to lay pipe in 1918. This machine permitted the completion of a pipeline 113 miles long in 120 days.

Oil arteries consisted of gathering lines which drew oil from different wells and fields to one storage center; lateral and main trunk lines leading from storage centers to refineries throughout the nation; and gathering-line and trunk-line pumping stations which were placed about 40 miles apart and equipped with powerful steam or internal-combustion pumping engines.

Marketing: The market for petroleum products, particularly gasoline anl kerosine, rose sharply. Gas engines were used in boats, grain elevators, water pumps, washing machines, churns, and for many other purposes. Farm mechanization and the increased sales of tractors, plus defense demands for tanks, planes, motor vehicles, etc., also increased



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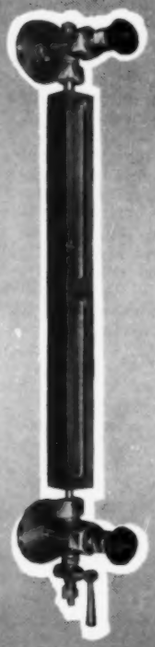

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the demand for oil products. Moreover, the increased use of the auto brought about better roads and, consequently, road oil and asphalt grew in sales importance.

In addition to a large domestic demand, exports also increased during this period. California Standard sold oil to the Orient, while eastern refineries sought markets in South America and Europe. The value of petroleum exports in 1917 more than doubled the 1910 figure of $94 million; and, by the end of the decade, it had reached $344 million.[71] Kerosine was the most important export item in each year of the period from 1910 to 1920, except 1918 when gasoline exports were higher. Canada in 1919 was by far the heaviest importer of American crude and oil products.[72] At the same time, more large companies were engaging in foreign production activity. For example, after the 1911 dissolution decree, Jersey Standard sought crude-oil supplies in Peru, Colombia, Venezuela, Asia, Africa, Oceania, and the Near East.

When the gas auto became popular, there were no service stations to meet the demands of a consumer on wheels. General merchants and hardware dealers had heretofore been the chief retailing outlets for petroleum products. In 1914, alert machine-shop owners recognized the opportunity to profit by furnishing gas to auto customers, and installed the sidewalk pump to aid sales. In addition, they offered air, water, and incidental services to their customers. To prevent a loss in business, hardware dealers and grocers also installed gas pumps. However, auto owners who wanted to save money by eliminating delivery costs were still able to buy sizeable quantities from the bulk plants.

As automobile registrations increased, company-owned and -operated drive-in service stations were adopted. Soon the middleman and dray truck drivers were eliminated as the companies were building many large bulk plants in order to service their stations and customers. Very often the large oil companies leased privately built stations and marketed their own products through these retail channels. Branded jobbers were used in the fringe areas of a company's territory, in sparsely settled areas, and in areas where an inexpensive type of distribution was required.[73] A branded jobber used the refiner's trade name and was required to maintain certain services and facilities for his customers. Unbranded jobbers, who distributed under their own brand name, were employed by independent refiners and in some cases by major companies. Large companies sought the highest possible integration in marketing because, through their own service stations, they were able to retain full control over selling prices, merchandising, and standards of service.

Lease arrangements were popular during the 1915-20 period on the premise that personal incentives would provide more efficient service than a company-operated system. Under a typical lessor-built provision, a property lease was granted to the supplier for a number of years. The landowner was then encouraged to borrow money in order to build a station which he subsequently leased to the supplier. The supplier then rented the station to the landowner or to a third party. Regardless of how they were set up, service stations spread rapidly, and by 1920 there were 15,000 of them handling the needs of over 9.2 million motor vehicles.[74]

With the growth in retail outlets, great stress was placed upon advertising and slogans in order to entice consumers to buy certain brands. Color and weight were emphasized in order to break the attachment that oil buyers had developed for dark Pennsylvania oil. Large-scale advertising, greater research producing more byproducts, and an intense integration activity brought about great strides in the marketing phase of the oil industry during the decade.

Summary: The industry grew and matured noticeably from 1910 to 1920. The breakup of the old Standard Oil Co. increased competition. Progress was made in oil refining with the introduction of the Burton process. Pipelines were more important, and marketing developed as the automobile made the availability and distribution of gasoline necessary. The industry also showed its ability and importance during World War I as it supplied fuel for military purposes and for our allies. After the war, exports rose and foreign production activity was stepped up by the larger companies.

An important development during this period was the increasing role of the government in the industry. Oklahoma initiated voluntary proration to reduce waste. The federal government formed the US Fuel Administration in 1918 in order to aid the procurement and distribution of oil for military purposes. When the war broke out, the US government had three naval oil reserves—two in California (Elk Hills) and one in Wyoming (Teapot Dome). These reserves were originally set aside by the government because geologists felt that they contained oil; but, after the war, they were transferred to private citizens who fulfilled certain necessary conditions. The National Petroleum War Service Committee, organized during this period, eventually evolved into the American Petroleum Institute, a national organization with a membership now numbering some 11,000 oil men.

1920-1930

The decade from 1920 to 1930 represented years of steady growth as progress was made in all phases of the industry. Many new fields were found, and the demand for petroleum products continued to increase at an amazing rate. More than ever, our economy was dependent upon oil.

Production Areas and Companies: Crude production more than doubled in this decade, rising to over

TABLE IV
USA CRUDE PRODUCTION, 1910-1920
(Thousands of Barrels)

1910	209,557	1916	300,767
1911	220,449	1917	335,316
1912	222,935	1918	355,928
1913	248,446	1919	378,367
1914	265,763	1920	442,929
1915	281,104		

Source: *Petroleum Facts and Figures*, New York, API, 1950, p. 147

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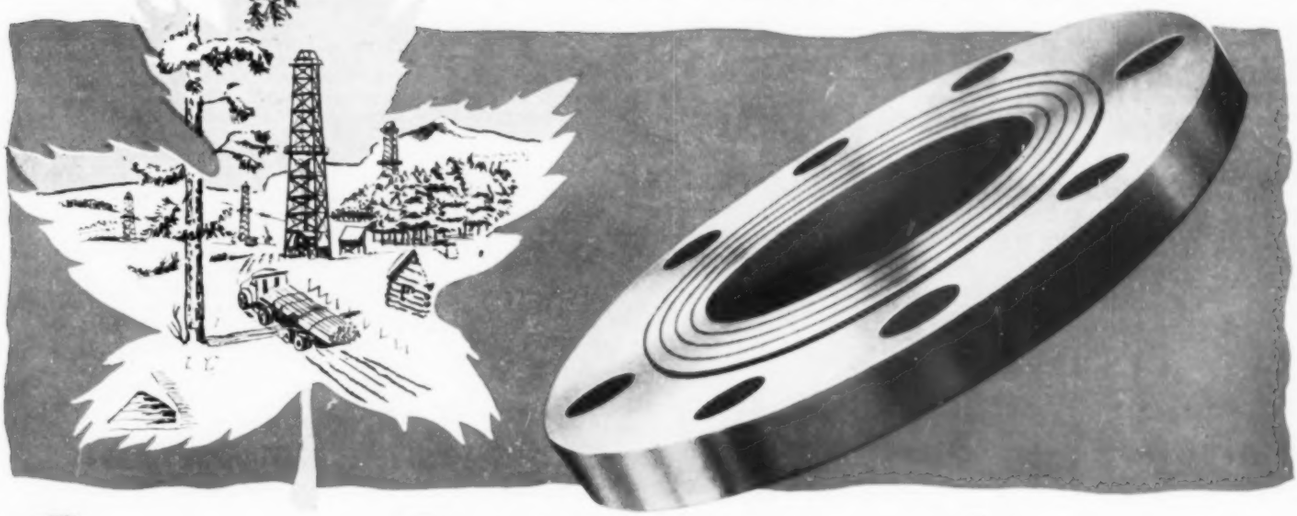

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one billion barrels in 1929 from 472 million in 1921.[75] This increase in crude production was due primarily to the successful efforts of oil operators in three states: Texas, California, and Oklahoma. In 1921, these three states accounted for 70.6% of all USA crude production, and in 1930 they supplied 81.8% of the total.[76]

Texas was fortunate not only because of its many new fields, but because many other ones made comebacks. In 1923, Corsicana was revitalized as a flush producer. Other fields, such as Spindletop and Ranger, also made astonishing comebacks. Oil was actually found at five different levels at Spindletop in 1925 by drilling some 1,500 ft below the known producing level. As a result, Spindletop production jumped to 21 million barrels in 1927 from 13½ million in 1926.[77]

Significant discoveries in Texas occurred at the Mexia fault zone, Powell field, Panhandle, Orange County, Pierce Junction, Permian basin, Nash, McComey, Yates, Van Zandt County, and East Texas. In 1925, Texas increased its output by 10 million barrels over the previous year. Its production continued to grow by 22 million barrels in 1926; 50 million barrels in 1927; 40 million barrels in 1928; and 39 million barrels in 1929.[78] From 1928 to 1930, Texas was the leading oil-producing state in the nation, and in 1930 it produced almost one-third of all USA crude oil.

Throughout this period, Oklahoma contributed one-quarter of the nation's crude supplies as important new fields were found at Burbank, Tonkawa, Cromwell, Seminole, and at Oklahoma City.[79] Oklahoma led the nation in oil production from 1916 to 1922, and again in 1927.

California led in production from 1923 to 1926.[80] This leadership depended primarily upon the development of known resources; the rich fields at Coalinga, Sunset, Midway, Kern, McKittrick, and San Joaquin all contributed to California's prominence at this time.

Important discoveries made in Louisiana included new pools at Bellevue, Cotton Valley, Lockport, Rodessa, and Zwelle. Arkansas became an important oil state in 1922 with the discovery of the Smackover field. By 1924, this pool had 1,000 wells with a million barrels capacity.[81]

Kansas supplied one-twentieth of USA crude from 1920 to 1930. Some of the new producing areas in that state were located at Gorham, the Wright pool, Ritz-Canton, and Hugotan. Wyoming and New Mexico were small contributors at this time, the latter being favored with gas wells at Artesia and oil wells at Hobbs.

Drilling was done by wildcatters, small independent companies, and the larger integrated companies. As independent operators, the wildcatters were largely responsible for finding new frontiers for exploration and development. Attracted by the high speculative value of oil, they were responsible for such great fields as Spindletop, Glenn pool, Mexia, and the East Texas field.[82]

In addition to the limited operation of the wildcatters, thousands of small companies appeared during the flush-production days after World War I. Most of these companies were able to prosper when offering their oil products in a period of great demand. However, as competition brought about integration, research and new refining techniques, many small companies went out of business.

Large independent companies were established and many prospered during the 1920's. Some of these new companies included Phillips, Skelly, and Sinclair which were built by successful wildcatters into major integrated operations. Meanwhile, the older and larger firms continued to pursue a policy of fuller integration. A basic reason for such activity was the chronic condition of oversupply which characterized this era. In order to dispose of their crude-oil output, the larger companies adopted forward integration to assure themselves of an access to refining, transportation, and marketing facilities. As a result, competition was increased in all phases of the industry.

With this increase in competition, Jersey Standard took measures to insure its position in the market. In 1927, it was made a holding company by turning over all its operations to affiliates and subsidiaries. The New York office of the company then became the governing agency over the many outfits held by the parent. In 1925, both Jersey Standard and Indiana Standard sought holdings in South America as the expansion of activities into foreign countries became more pronounced.

A most important problem was resolved in 1926 when the government allowed oil companies a 27½% depletion allowance. The concept of a special tax deduction for the exhaustion of oil and gas properties actually originated in 1913. At that time, Congress granted companies an allowance to cover the capital consumed in the operation of an oil and gas well. The capital in question was the value of the property as of March 1, 1913, or the cost, if acquired after this date. The allowance was no longer deductible once the capital investment was recovered. In 1918, the base was enlarged to cover the value of the property at the time of discovery, or within 30 days thereafter.

Then, recognizing the high risk involved in searching for oil and also the need for capital to maintain new operations, the government eventually permitted the oil companies to deduct 27½% of their gross income for depletion purposes—the amount allowed for deduction was not to exceed 50% of net income. This tax benefit is significant because it represents government interest in maintaining readily available supplies of petroleum.

Production Techniques and Methods: The introduction of the core drill in 1927 enabled the geologist to determine more accurately the subsurface structure of an area. The core drill consisted of a long steel tube which had diamond chips, carborundum, or teeth of special steel at one of its ends. The tube was then lowered into the hole, and, when rotated, it cut a ring which left a core or rock in the center of the pipe.[83] The core was then brought to the surface and studied by geologists.

Other innovations included a cylindrical rotary electric pump to raise fluids from the bottom of the well; the injection of hydrochloric acid into wells found in limestone reservoirs to dissolve the limestone; and water-lift and air-lift for secondary-recovery purposes.[84]

The portable rig, introduced at this time in the Louisiana marshlands, reduced costs and permitted access to difficult locations. Drilling barges used during the '20's were a portent of later offshore drilling activity. The first electrically drilled well is credited to Frederic Hild who developed the idea of using a differential gear to change the speeds of

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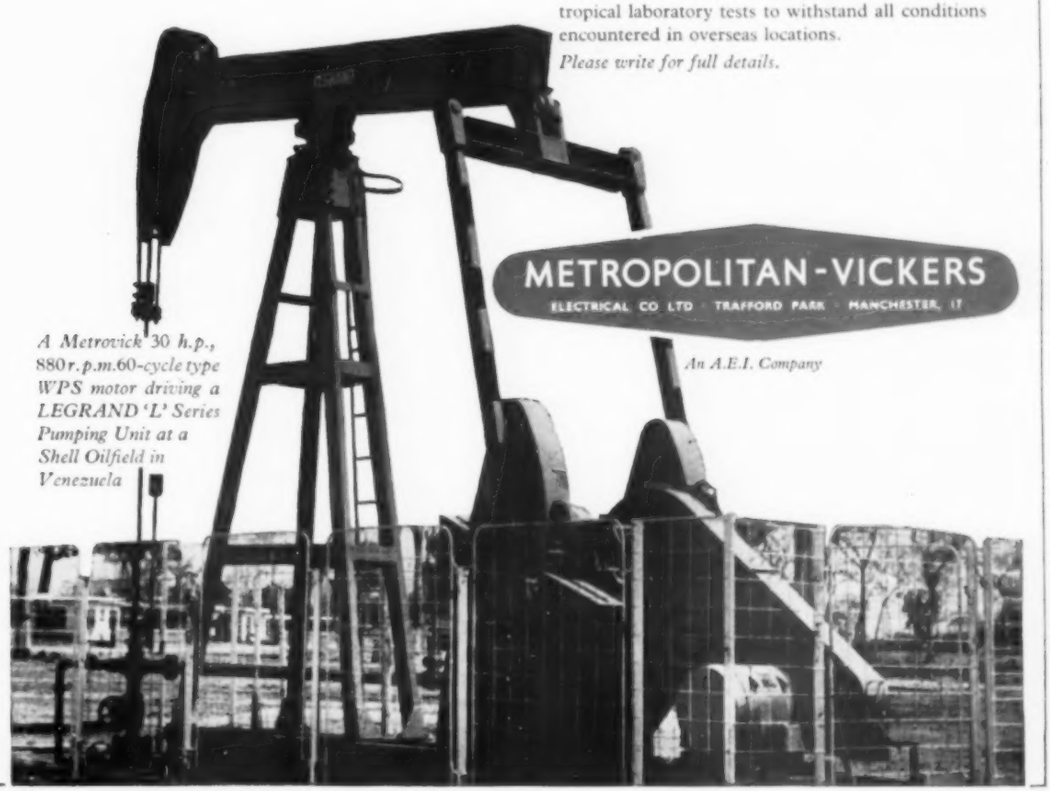

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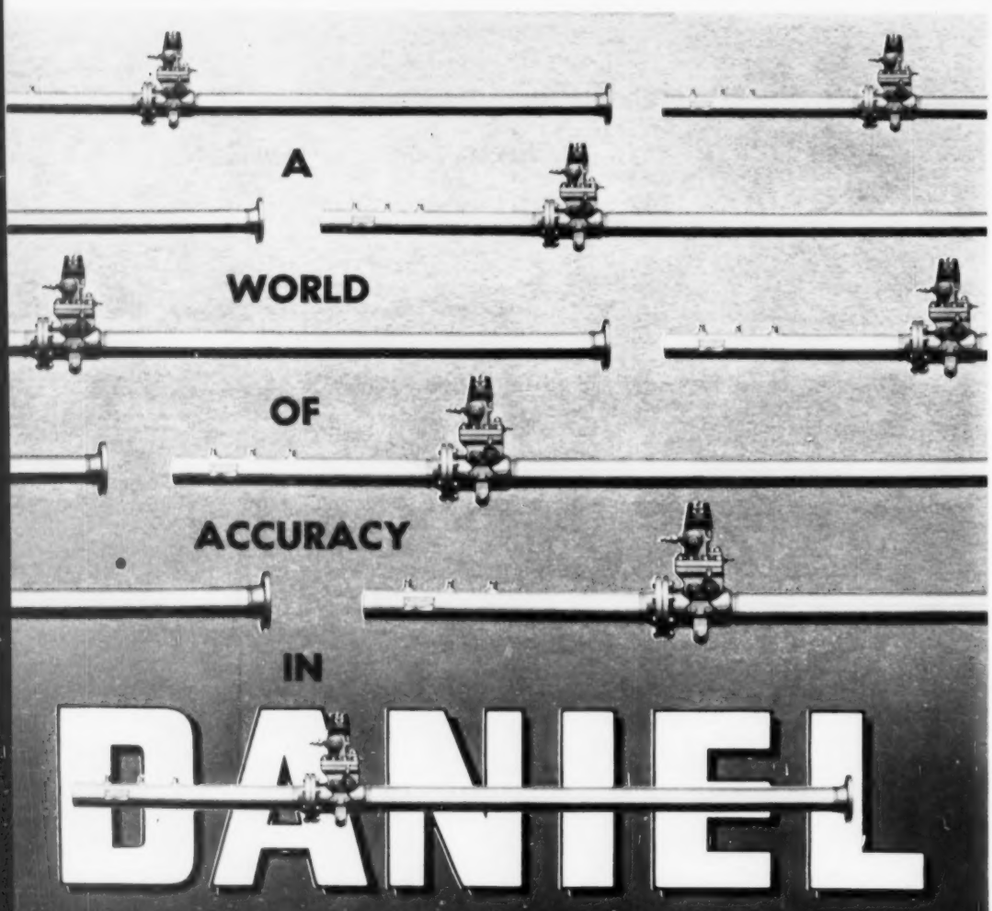
motors used in drilling machinery. For example, for the cable-tool method, a high speed is needed for pulling tools, bailing, and setting casing; while a lower speed is needed for ramming bits. This technique was first employed in 1923 in California.[86]

The competitive atmosphere of the '20's resulted in rapid oil drainages and consequent fluctuations in prices. In order to counteract the waste caused by the application of the "law of capture," conservation programs were initiated. The program of voluntary proration as attempted by Oklahoma in 1916 failed during the flush periods of the Cushing and Healdton pools. In 1926, the state undertook to balance supply and demand by assigning ratable takings through a state regulatory body which could enforce its decisions. This inaugurated the great controversy over conservation and proration.

The American Petroleum Institute opposed proration at first because it felt that oil supplies were abundant enough, but the Federal Trade Commission argued for a better use of our petroleum resources through conservation. The independent or smaller companies at first opposed any restrictions on domestic production, because they felt that the larger companies would not have to comply with regard to their foreign holdings. However, the need for some sort of control became increasingly apparent with the rapid discovery and depletion of many new fields during the late 1920's. Eventually, most of the states took the initiative and passed conservation laws to limit withdrawals. In 1928, the Texas Railroad Commission sought to limit production to current reasonable market demand. It was not until 1932, however, that the state courts finally affirmed the commission's right to limit production in order to prevent waste through ratable takings. By helping to eliminate conditions of scarcity and glut, conservation prevented violent price fluctuations and, therefore, brought a greater stability to the petroleum industry.



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Another advance made in the production of petroleum was the introduction of unitization in Texas. Under this plan, the oil-producing companies or wildcatters consolidate their leaseholdings in a particular area, and each company then shares proportionately the expenses and profits accruing from that area. Unitization thus helped to reduce excessive drilling and waste of valuable reservoir pressures. Along with conservation and proration, it marked a decade of significant progress in the correction of wasteful production methods.

Refining: The struggle toward greater integration provided certain market advantages to companies with large refineries. This was so because of the many fixed costs associated with the refining of petroleum. In addition, the flexibility of the equipment permits the yield of individual products to be adjusted according to changing market conditions. Thus product differentiation was stressed, and it served to increase competition in the industry.

Thermal cracking enabled the companies to obtain a higher yield of gasoline and other valuable products from the crude. Different versions of thermal cracking arose in this period: bulk pressure cracking, tube-still cracking, the Dubbs, the Holmes-Manley cracking processes, the tube-and-tank cracking process, and the Cross cracking process. Cross-licensing was a common practice to avoid litigation and to provide the licensees with the benefits of a competitor's findings. Such agreements were not always looked upon with favor by the Justice Department.

The recovery of gasoline from crude was only about 42% when Jersey Standard acquired the rights to the Bergius process from the I. G. Farbenindustrie. Hydrogenation—a result of the Bergius process—was expensive, but it permitted a 100% recovery. It never became a widely used process in the USA. Improved quality of gasoline through cracking and TEL enabled Walter Chrysler to enter the automotive market in 1924 with a high-speed high-compression motor. From 1925 to 1930, fuels of high antiknock quality were at a premium on the market.

The construction of six large refineries in Texas with a combined capacity of 365,000 b/d made Beaumont and Port Arthur the largest refining center in the United States. Total crude runs to stills increased to 927 million barrels in 1930 from 443 million in 1921.[86]

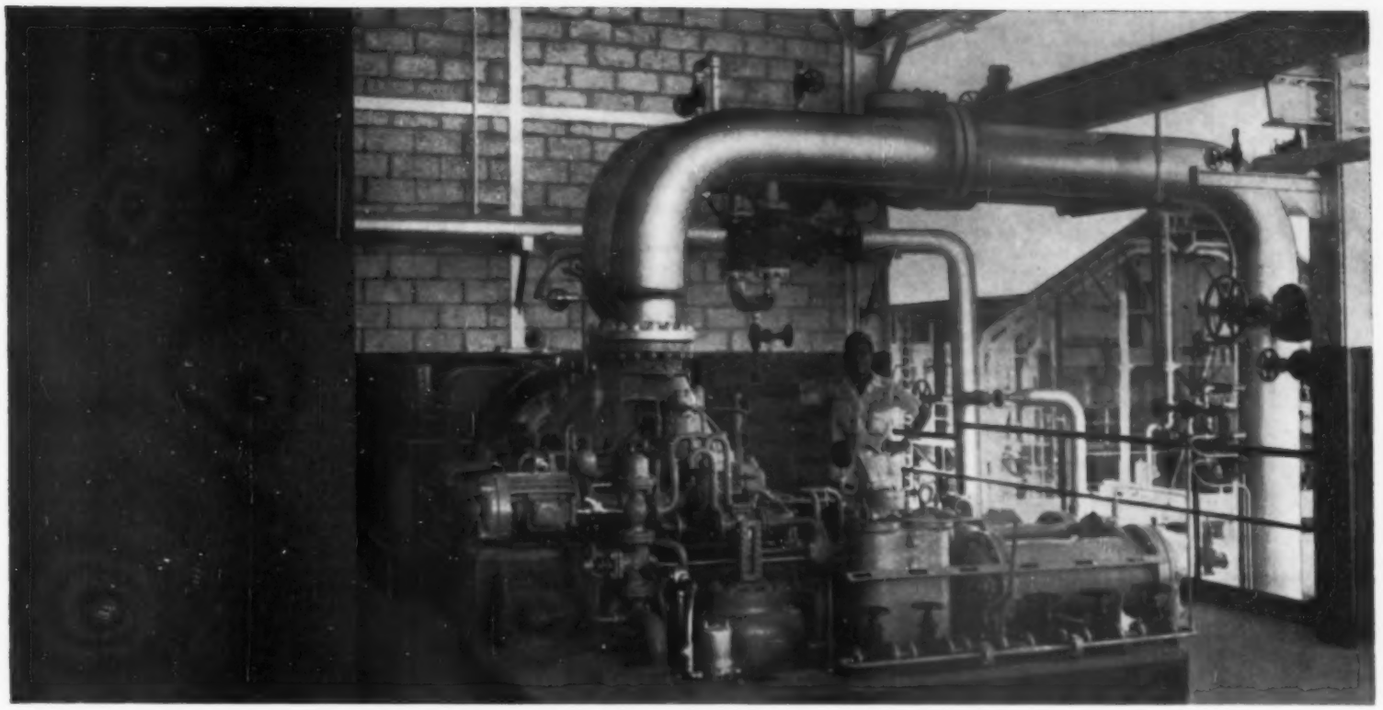
Transportation: Tankers annually moved 113 million barrels of petroleum from Gulf ports by 1926, and most of their cargo was taken to refineries on the Atlantic Coast.[87] Again the lower cost of tanker transport made it a more attractive means of transportation than rail delivery. Although the USA increased its tankship fleet to 371 tankers from 314 between 1921 to 1930, it suffered a relative decline in its per cent of world tonnage—dropping to 35.8% in 1931 from 54.4% in 1921.[88]

Pipeline mileage rose to 110,650 miles in 1930 from 64,367 miles in 1920.[89] Thousands of miles of pipelines moved from Texas, Oklahoma, Kansas, and Louisiana to refineries mostly in Illinois, Indiana, and the Atlantic Coast areas. From 1927 to 1929, 5,500 miles of pipes were laid at a cost of $150 million.[90]

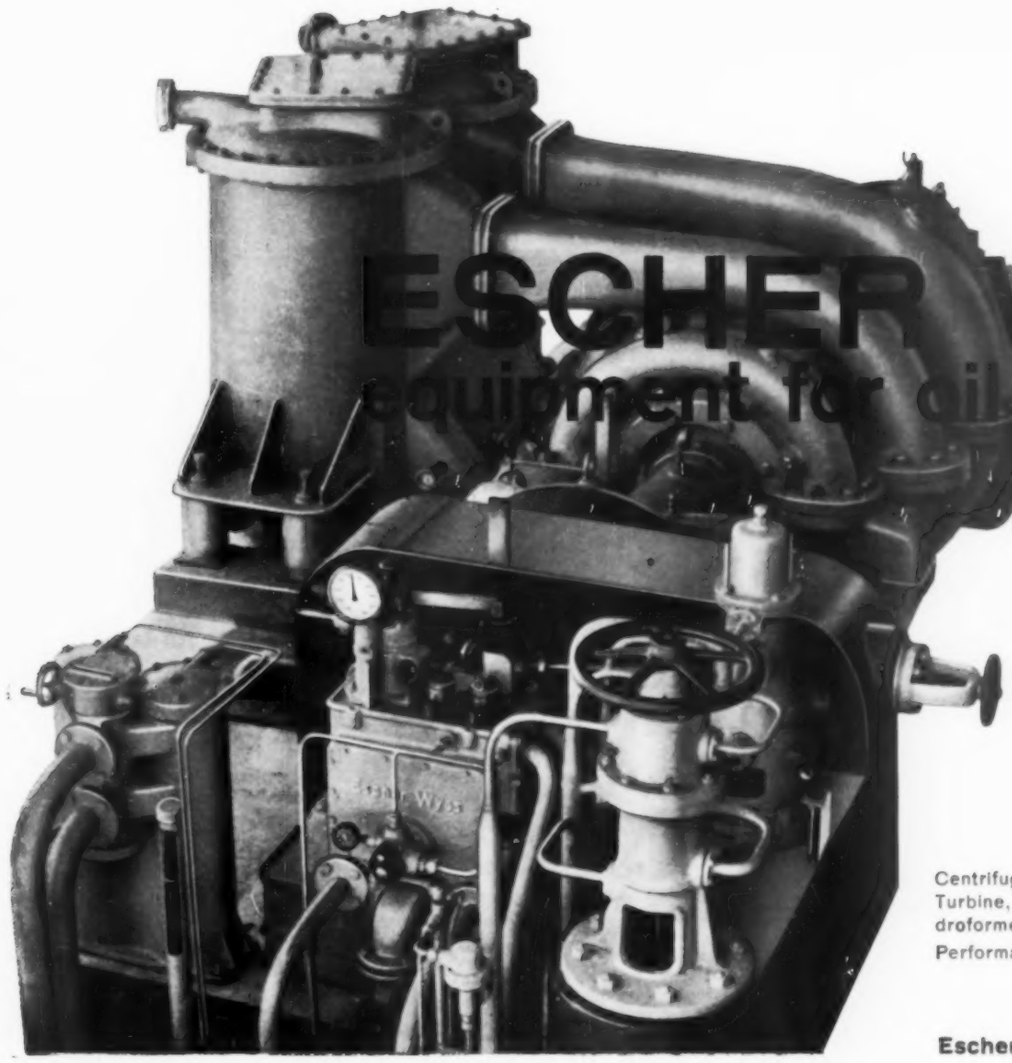
Improvement in laying pipelines enables the task to be accomplished with one-half the labor formerly required.[91] A new pipeline laying machine was able to screw the ends of the pipe together as each section was put in place. Thus, the work force for this operation was cut in half. Through the constant addition of more and more lines, the highly populated areas of the country were assured of crude and oil products for their industrial and consumer needs.

Marketing: Gasoline for automobiles still made up the primary market for petroleum. Motor-vehicle registrations increased to 26.5 million in 1930 from 10.5 million in 1921.[92] However, fuel for airplanes also became important during this decade. Chiefly a military weapon in World War I, planes took over a greater role in the postwar period as they were used for passenger transportation, crop dusting, mail delivery, and aerial mapping. The number of planes manufactured increased to 6,034 in 1929 from 789 in 1925. From 1926 to 1930, gasoline gallonage for civil flying purposes jumped 600% to 14 million gallons yearly from 2¼ million.[93]

In 1921, gasoline production outstripped kerosine by a 3-to-1 ratio. Persistent pinging (knock) in the cylinders was reduced considerably in 1921 by the addition of tetraethyl lead.[94]



Centrifugal Recycle Gas Compressor with sealing oil system, installed in an oil refinery



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Advertising became an even more important marketing tool during this decade. Indiana Standard spent over $4 million in 1926 on advertising alone.[95] In the years 1927 to 1929, commercial advertising was pursued through such media as newspapers, billboards, road maps, station identification signs, posters, movies, and radio. Thus, we see that the most important development in marketing was the effort put into promoting sales and certain brands.

Natural Gas: Expansion of the industry in the '20's included the development of natural-gas fields and producing facilities. Natural gas became a valuable blending agent for upgrading the quality of poor fuels. Byproducts of natural gas included propane, butane, and helium. Another byproduct, carbon black, is useful in printers' ink, polishes, paints, yarnishes, and rubber products. Although the Natural Gas Manufacturing Assn. in 1919 proved that natural gas, mixed with the proper amount of naphtha, was a suitable motor fuel, it did not compete with gasoline as such.

Most of the natural-gas pools in the United States were located in the Southwest. The early importance of natural gas was a foreshadowing of the larger role it would have in our economy in later years.

Summary: The decade 1920 to 1930 represented a period of great growth in production. Just as very many new and larger fields were discovered, so too were new uses found for oil. Moreover, progress was made in the orderly production of petroleum through the application of conservation laws.

Mention should be made of the formation of the Independent Petroleum Assn. of America by a group of independent oil men in 1929. One of the expressed aims of this group was to seek congressional action to slow down foreign imports of crude oil and petroleum products. The association originally was set up to exclude "any company or individual who is engaged in importing crude oil into the United States, refining crude oil that is imported into the United States, or distributing products made from imported crude oil within the United States."[96]

TABLE V
USA CRUDE PRODUCTION, 1920-1930
(Thousands of Barrels)

1920	442,929	1926	770,874
1921	472,183	1927	901,129
1922	557,531	1928	901,474
1923	732,407	1929	1,007,323
1924	713,940	1930	898,001
1925	763,743		

Source: *Petroleum Facts and Figures*, New York, API, 1950, p. 147

1930-1940

From 1931 to 1935, all phases of petroleum operations experienced little growth as the worldwide depression held production, refining, marketing, and pipeline construction to 1929 levels. The industry was generally characterized by overproduction of crude oil, decline in consumption, with subsequent heavy inventories and a falling off of petroleum exports.[97] As a result of this situation, the struggle for survival served to sharpen competition.

The crisis in domestic oversupply brought about the first imposition of import duties on foreign oil imports. In June 1932, Congress passed the Internal Revenue Code establishing an excise tax of 21 cents per barrel on crude oil and petroleum products, with separate rates of $1.05 and $1.68 per barrel for gasoline and lubricating oil, respectively.

Production Companies and Areas: Not all crude-oil producers had excess supplies during these years, although for the country as a whole the period was one of chronic oversupply. Individual geographic areas tended to alternate between periods of great abundance and great scarcity as many new discoveries were developed, produced, and exhausted rapidly. Thus, although the total available supply in the United States was sufficient to meet all requirements, particular geographic areas were often in short supply.

From 1931 to 1940, California and Texas assumed the leadership in oil production for the country. Together, they produced about 60% of the total production, with the newly discovered East Texas field contributing greatly to the prominence of Texas.[98]

The industry showed considerable activity in two other areas: shale mining and offshore drilling. Mining became prominent in the '30's as good lubricating stock was found in the shale and sandstone 50 ft to 250 ft deep, about 15 miles southwest of Nacogdoches, Texas.[99] Large shale deposits were also found in the Colorado Rockies. Despite the low gasoline and kerosine content of shale, sufficient uses were found to warrant the mining of this mineral. Moreover, it was possible to crack shale into many hydrocarbon combinations. Union Oil Co. of California became a pioneer in this field.

Offshore drilling began with an attempt made in the Gulf of Mexico in 1938. By means of an offshore platform large enough to house equipment and personnel, drilling on the continental shelf off the coasts of Texas and Louisiana became more active. As many as seven wells were drilled directionally from a platform. One method used to achieve this was the "whipstock," whereby a bar of steel was inserted in the bottom of the hole at the point where the deviation was desired. Another method employed is a "knuckle joint" or drilling tool which is so hinged that it can be properly deflected at any desired angle.

This is high-cost drilling due to the need for exceptionally sturdy equipment to withstand wind and waves, for pipelines from the barge to the shore, electrification of the platform, special craft to transport personnel and equipment, etc. A barge for shallow drilling costs from $200,000 to $250,000, while one for deeper drilling costs as much as $1½ million.[100] Though most of the activity in the '30's was confined to the shallow waters off the coast of Louisiana, operational costs were prohibitive for all but the larger corporations.

Competition continued to increase during this decade. The rivalry between the former members of the old Standard Oil Trust was intensified by the encroachment of new companies upon the established markets of these older companies.[101] The five larger integrated companies, all former mem-

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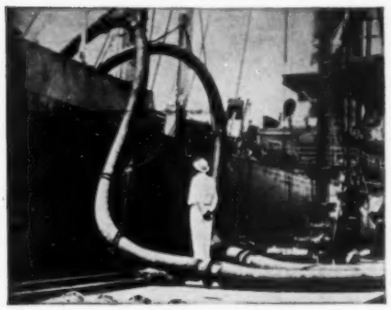

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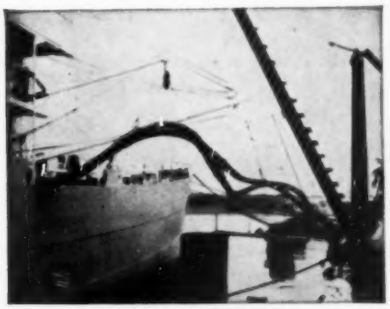

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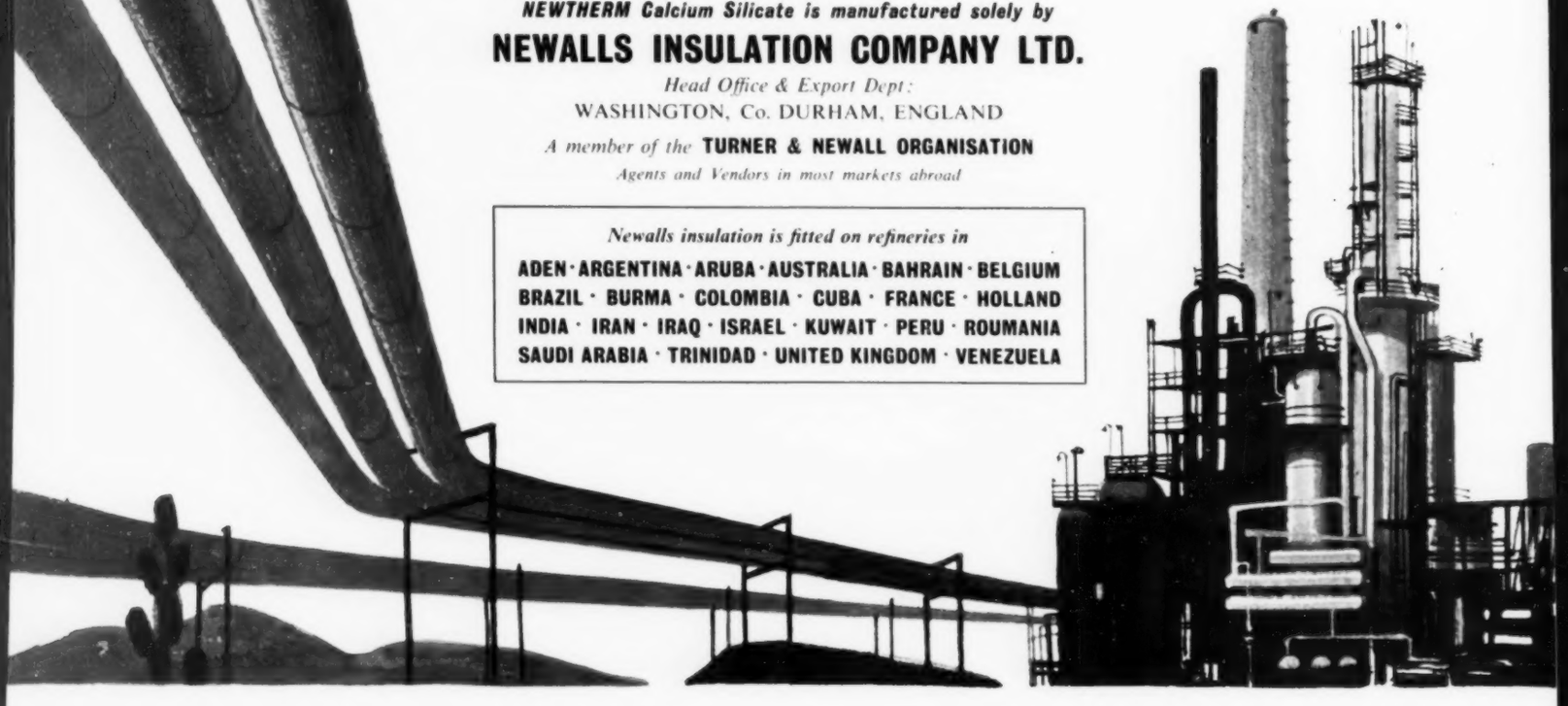

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bers of the old Standard group, were Standard of New Jersey, Socony-Vacuum, Standard of Indiana, Standard of California, and Atlantic Refining. The size and degree of vertical integration in the industry became the subject of congressional criticism in 1939.[103] Most of the criticism concerned the ownership of pipelines with refining and marketing operations. It was found that 20 integrated companies owned or controlled 57.4% of the crude-oil gathering-line mileage, 89% of the crude-oil trunk-line mileage, and 96.1% of the products-line mileage.

The larger oil companies continued their foreign-oil activity as Venezuela remained the largest source of American oil imports. On a dollar basis, the USA maintained a favorable balance of trade in oil. Imports were generally confined to crude and fuel oil, while exports consisted primarily of gasoline, kerosine, lubricating oils, and other petroleum products.

The position of the oil industry in the American economy in the 1930's may be judged from the fact that, in 1937, there were 789,540 employees in all four phases of the industry and the average weekly earnings for crude petroleum production workers was $33.41 as compared to an average for all manufacturing industries of $24.24.[105] In addition, the total amount of taxes paid out by oil companies to federal and state governments in 1938 amounted to about $1.2 billion.[106]

Production Techniques and Methods: Geophysics —the application to geology of principles of magnetism, attraction, the pull of gravity, the speed of sound waves, and the behavior of electrical currents—accelerated in this period.

The use of thermal, electric, radioactive, and neutron well logging to determine the resistance of various formations to electric currents, temperatures, and radiation also aided the scientific search for oil.

Directional drilling was utilized during the '30's to drill a well beneath the state capitol of Oklahoma City from a derrick 400 ft away. This technique was also used to control "wild" or burning wells by drilling a relief well nearby to pump water and mud into the formation. We have already seen how directional drilling was utilized to develop oil reserves offshore.

Conservation: The East Texas pool was a scene of unrestricted production which depressed the national oil price during the early years of the decade. The efforts of the Texas Railroad Commission to restrict production failed as the producers responded with countervailing injunctions.[107] In addition, offset wells sprang up with narrow interspaces. Consequently, sound conservation and engineering practices and the needs of the market were often ignored. Flush production in Texas dropped crude prices to 13 cents per barrel in August 1931,[108] while costs of production increased as the number of wells which became pumpers increased rapidly throughout the area.[107]

In August 1931, Governor Sterling proclaimed martial law in East Texas. For three weeks, the state militia exercised a strict surveillance over production, while market conditions were carefully studied in order to develop sound conservation facilities and solve the differences between the small independent companies, which favored unrestricted production, and the major companies with surplus supplies, which desired controls.

When the field was reopened, the commission ordered all wells limited to the production of 225 b/d. However, even this order was circumvented as hidden pipes not connected to gauges or cutoffs removed excess illegal or "hot oil" from the controlled well.

During this same period, Kansas and Oklahoma vested oil control authority in their corporation commissions. The Arkansas Oil and Gas Commission, the Department of Oil Conservation Commission in Louisiana, and the Oil Conservation Commission in New Mexico also administered controls in their respective states.

On February 28, 1931, the governors of Texas, New Mexico, Kansas, and Oklahoma met to discuss an interstate compact for the purpose of regulating the flow of oil. Long discussions were held over a two-year period until the passage of the NRA in June 1933, plus the adoption of the "Code of Fair Competition," temporarily checked this movement. With the repeal of the NRA in 1935, California, Illinois, Kansas, New Mexico, Oklahoma, and Texas approved the Interstate Compact to Conserve Oil and Gas. This compact gave the member states the means for taking required cooperative action, and placed upon them a moral obligation to enact and enforce laws to prevent physical waste. As required by the United States Constitution, Congress approved the compact.

In order to halt the flow of "hot oil," Senator Connally of Texas succeeded in passing the Federal "Hot Oil" Act and, through its enactment, the states were provided with the means of enforcing their conservation programs. Another contribution made by the federal government to the conservation programs of the states occurred through the activities of the Bureau of Mines in publishing findings with regard to supply-and-demand conditions in the industry.

The conservation programs of the various states came to embody several principal features. The first of these was a provision for preventing production in excess of a field's maximum efficient rate (MER). This procedure provided for the conservation of valuable natural reservoir pressures, and thus more oil could be removed than would be the case if wide-open production were permitted. Engineers determine the maximum efficient recovery rate at which the wells of each field can be produced, and state laws prevent any faster flow. Second, most of the oil-producing states adopted regulations controlling the spacing of wells, and in a number of instances embodied acreage factors in their allocation formulas. Another major feature of most conservation laws was the adjustment of production to market demand at times when production at MER provided more oil than the market could readily absorb. Based on information from the Bureau of Mines and from the crude buyers, an allowable rate of production was arrived at by the individual states.

Because of the great progress made toward the conservation of a basic natural resource, it is obvious that the 1930's was an important era for the oil industry.

Refining: Petroleum refineries were located in 32

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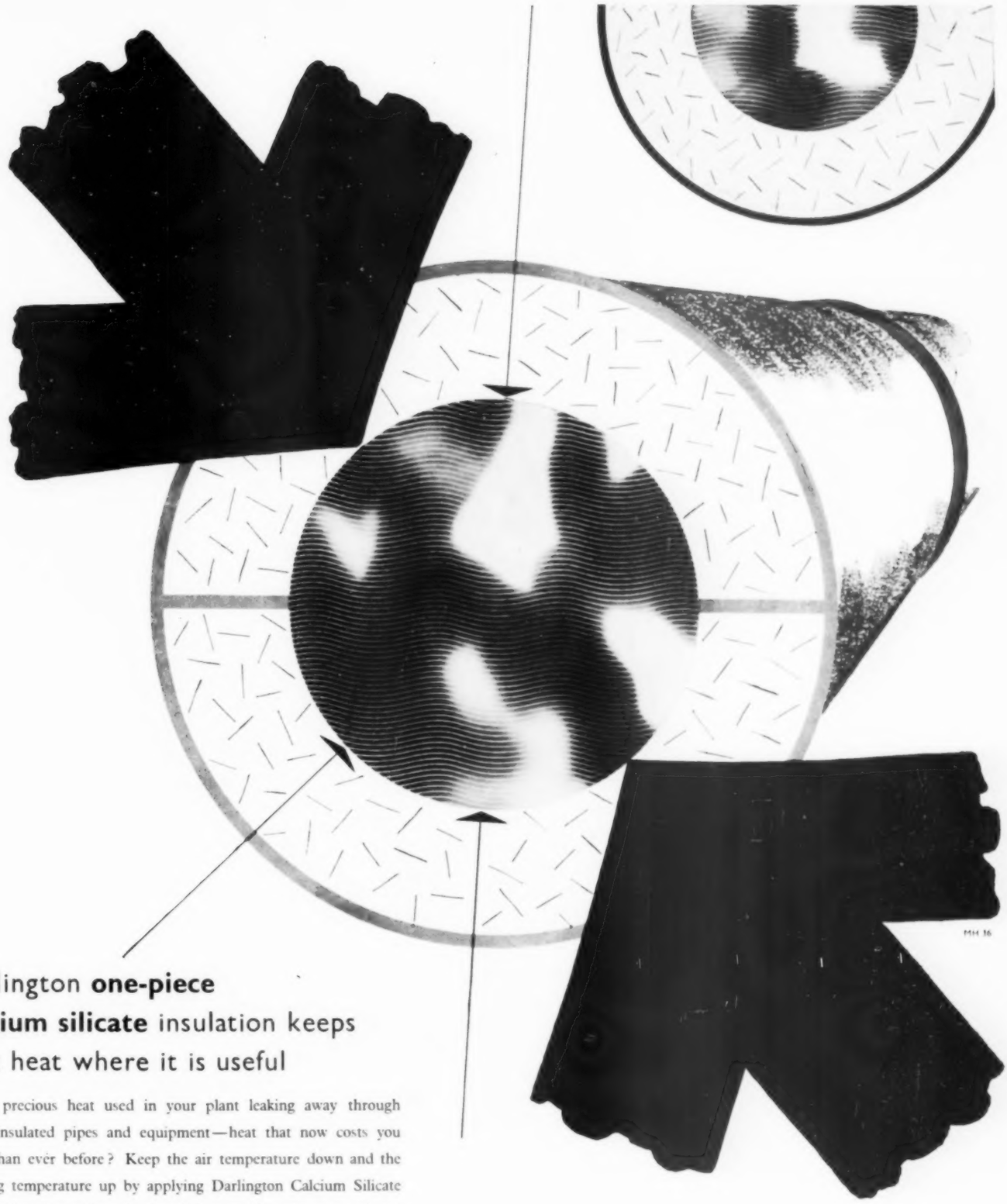

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states in 1938, but Texas had almost 30% of the total refining capacity.[108] A further geographical breakdown of all refineries shows that about 41% were located on the Gulf and Atlantic Coasts; 38% in the interior; and 21% in California—with the world's largest skimming and cracking plant located at Whiting, Ind.

In the early '30's, expansion of refineries was kept at a minimum due to the depression. Gradually, however, there appeared a trend toward consolidating different refining operations into so-called "combination units." These units offered such advantages over conventional refineries as better heat exchange and the use of surplus heat from one step to another; reduced refinery labor costs; and reduced construction and operating costs from the use of a single piece of equipment for several operations.[109] The 1935 refinery had a combination unit for crude-oil distillation, thermal cracking, and thermal reforming.

In 1938, catalytic cracking was developed to the commercial stage. The Houdry process, a pioneer in the field, was able to produce fuels with better antiknock qualities, higher octane ratings, and higher lead susceptibility. This process yielded 82% gasoline per barrel of crude as compared to 55% extracted in 1930 under the older methods.[110]

Polymerization, or the combining of smaller molecules into larger ones, employing both thermal and catalytic principles, aided in the synthetic production of gasoline.

Hydrogenation also experienced rapid development in the '30's. Whereas straight-run distillation separates the oil into its constituents without disturbing the structure of the molecules, and both cracking and polymerization break down the molecules in order to build new ones, hydrogenation builds hydracarbons from carbon compounds by joining them to free hydrogen atoms under ideal chemical conditions.[111] Thus hydrogenation is capable of furnishing any petroleum product in any proportion desired from any grade of crude oil. Hydrogenation plants were erected at Bayway, N. J.; Baton Rouge, La.; and Baytown, Texas. By converting all parts of crude into gasoline and thereby eliminating refinery residues, they produced a good-quality gasoline.

Propane dewaxing was initiated in 1932 at the Wood River, Ill., refinery. Propane is a good solvent for oil, but not for wax—making it possible to produce an oil remaining more fluid at low temperatures. This was an important innovation for use in the automobile.

The first significant automation with regard to quality control occurred with the use of the "off-on" temperature control of the fractioning tower. This operation permitted a uniform separation of light products and heavy materials recycled back to the pipe still. By 1935, uniform control of flows and pressures was achieved to the extent that the process was governed from a central control house.

Jersey Standard and the Shell Oil Co. were especially active in the expanding field of petrochemicals. Most companies preferred a Gulf Coast location for such operations, because the mild climate of the area enabled them to use fuel for their refinery operations which was not needed as a consumer product.

Transportation: The aggregate length of pipelines in 1939 was about 122,500 miles,[113] most of which was controlled by 58 companies engaged in interstate trade. In 1937, they accounted for 84% of the total pipeline mileage.[114] Competition in this field was keen, and rates were drastically reduced during the decade.

Railroads continued to carry a comparatively smaller share of petroleum freight. From a total of 66 million tons hauled in 1931, the amount declined to 61 million tons in 1940.[114] Once again, this decline points up the inability of railroads to compete with cheaper means of transportation, especially the pipelines. The average cost of pipeline transportation did not exceed four mills per ton-mile in 1939, whereas rail freight cost about eight mills per ton-mile.[115]

The USA oil fleet numbered 750 tank ships in 1939.[116] Representing an investment of $530 million by 1940, these tankers hauled nearly one-third the crude traffic in the United States and over half the traffic in refined products.[117] With automatic loading and unloading facilities, the tanker surpassed the pipeline in efficiency. The availability and cheapness of this means of transportation were instrumental in the location of refineries in coastal regions.

Marketing: Gasoline consumption for automobiles continued to increase during this period as motor-vehicle registrations rose to 32 million cars in 1940.[118] At the same time, the average octane rating for regular-grade motor fuel was 74 as compared to 62 in 1931.[119] The average retail price of gasoline (excluding any sales taxes) dropped to 14.07 cents per gallon in 1938 from 21.06 cents in 1923.[120] Total USA consumption of fuel and lubricants by commercial and civil aircraft alike also increased during the '30's. In 1931, the aviation industry used about 28 million gallons of gasoline, and in 1940 the figure stood at about 88 million gallons. Similarly, lubricant usage increased by 681,246 gallons.[121] In addition to the growth in demand for motor and aviation fuels, there were approximately 1.7 million homes which used oil for heating purposes.[122]

The forward movement of refineries into retailing activities continued through 1935, with the result that competition in marketing became more intense. In order to acquire new dealer outlets, refiners offered attractive lease and license programs which included liberal rental terms for stations, price concessions on gasoline, and the free installation of pumps and tanks.

In an effort to lower distribution costs, companies sought to make deliveries of refined products by large truck transports directly from refineries or terminals to the service station. In so doing, the bulk plant was bypassed. Extensive product pipelines also enabled the companies to reduce their bulk-plant operations. Not only were costs reduced, but marketers were able to operate their facilities more effectively, since they had a more stable supply of products. Service stations increased in number as the number of bulk-plant operations decreased, and in 1935 there were 197,568 such stations in the United States.[123]

Forward integration into marketing was due mainly to the shrinking profit margins and market opportunities which the oversupply in crude oil

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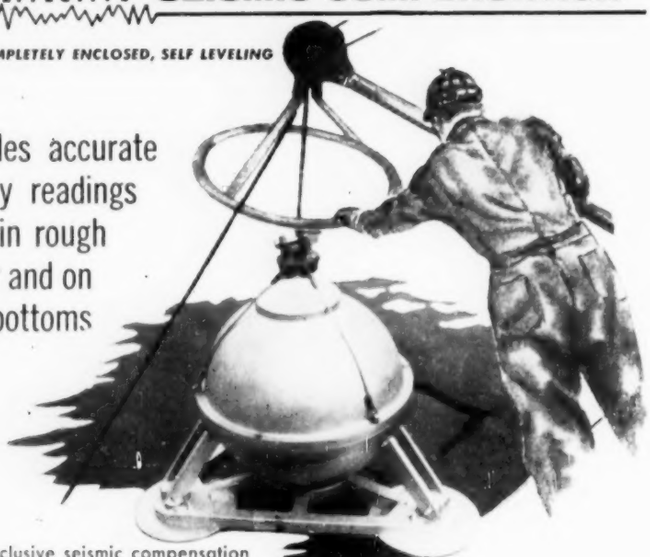

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prompted. However, the oil industry was not without disintegration attempts during the 1930's. In 1935, this movement gained momentum as companies leased more of their company-owned and operated service stations to private operators.[124] The disassociation of the retail function from refining operations was best exemplified by the "Iowa Plan."[125] This plan allowed privately leased and operated stations to switch from one supplier to another. One of the incentives to disintegration was a tax on chain-store operations.

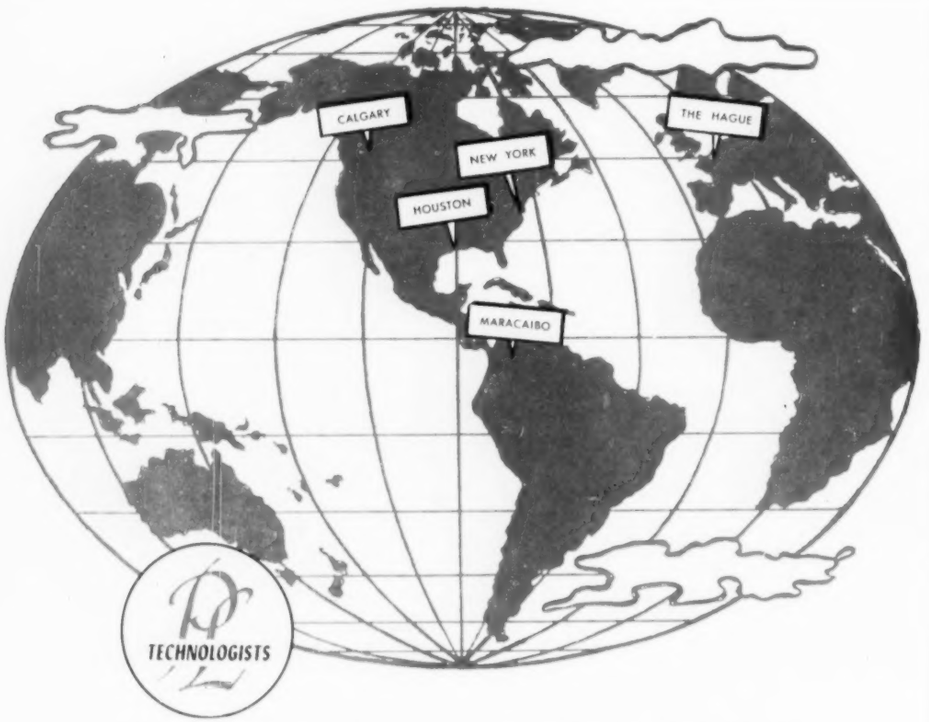
During the depression, the industry began to merchandise motor oil in cans. This practice, initiated in 1932, did much to simplify and facilitate the marketing of petroleum products.

Summary: The most significant development which occurred in the decade 1930 to 1940 was the increased application and perfection of conservation laws. The tremendous waste which had characterized the early growth of the petroleum industry was eliminated by the practice of sound conservation methods and the study of market conditions. Thus, market prices were more stable as supply and demand were kept in fairly close balance. This achievement added great stability to the industry and encouraged the growth and development of refining, transportation, and marketing.

TABLE VI
USA CRUDE PRODUCTION, 1930-1940
(Thousands of Barrels)

1930	898,011	1936	1,099,687
1931	851,081	1937	1,279,160
1932	785,159	1938	1,214,355
1933	905,656	1939	1,264,962
1934	908,065	1940	1,353,214
1935	996,596		

Source: *Petroleum Facts and Figures*, New York, API, 1950, p. 147



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Oil proved to be an absolute necessity during world War II. Of every two tons of exports sent to USA allies and troops during the war, more than one ton was petroleum in some form.[126] Moreover, with the loss of natural rubber sources in the Far East, it was essential that American industry produce a necessary volume of high-quality synthetic rubber. A government expenditure of $700 million was used to construct 44 privately run synthetic plants capable of producing approximately one million tons per year. The most common form of synthetic rubber was that made from butadiene and styrene—both petroleum products. Smaller quantities were made of butyl rubber, which is derived from oil-refinery gases.

In addition to supplying the basic components for synthetic rubber, the petroleum industry provided immense supplies of 100-octane gasoline, automotive and diesel fuels, lubricating oils and greases, heating oils, bunker fuels, toulene for TNT, alcohols, and numerous other products. Thus the industry had to meet the heavy demands of our military machine in addition to the requirements of the business and consumer sectors of the economy.

Production Areas and Companies: The request for greater oil production by the Petroleum Administration for War in December 1942 drew forth greater efforts by the industry to surpass previous levels. In 1941, the industry had a crude-oil output of 1.4 billion barrels, and in 1945 this figure grew to 1.7 billion barrels.[127]

Throughout the war, Texas out-produced all other states and, in 1945, its yearly production amounted to about 755 million barrels. A major discovery made in Scurry County helped Texas to maintain its leadership. California, its nearest rival, was aided by new finds at Russell Ranch and South Cuyama, and it produced 326 million barrels in 1945.[128] Although exploration and drilling reached new highs in California, the excessive cost of transportation restricted domestic marketing to its own area, as well as to Oregon, Washington, Arizona, and Nevada.

The most significant wartime discovery occurred at the West Edmond field in Oklahoma, and it enabled Oklahoma to take third place temporarily among the oil-producing states. Gulf Coast discoveries in Louisiana, however, soon brought that state back to its position ahead of Oklahoma.

In 1944, oil was found in Florida and Alabama. In 1949, 37,633 wells were drilled—twice as many as had been drilled in 1934.[129] In that same year, Texas, California, Louisiana, and Oklahoma accounted for almost 70% of all USA crude production.[130]

With the diplomatic aid of the government, American oil companies were able to undertake large-scale exploratory programs in South America, the Middle and Far East. Soon large refineries were being constructed in Venezuela, Mexico, Ecuador, Saudi Arabia, and Kuwait. American direct investments in foreign petroleum operations amounted to $14 million in 1943.[131] Since most foreign oil deposits are located in economically underdeveloped nations, much of this appropriation had be be used for highways, hospitals, and other basic facilities.

Natural Gas: The development of natural-gas reserves and the construction of more pipelines after the war resulted in a widespread changeover from manufactured to natural gas. Natural-gas production increased to 7.5 billion cubic feet in 1949 from 3.7 billion in 1940.[132]

The oil industry spent over $10 million on research in 1949 in the hope of finding an inexpensive method for converting natural gas, coal, and oil shale into oil products. Eventually, commercial plants were constructed for the conversion of natural gas to oil, but the refining of petroleum products from coal and oil shale remained uneconomical.

Production Techniques and Methods: Improvements in rotary-drilling equipment made vast new oil reserves accessible. The average depth of a well in the 1930's was 6,000 ft, but in 1949 a well drilled in Wyoming reached a depth of 20,000 ft.[133]

The use of directional drilling in marine operations became more important. By the use of special tools, tributary holes were drilled from the one central well. Other improvements in drilling included greater application of paleontology and microfossil study for exploration of geological structures; improvements in drilling fluids, metals and tools for cutting; the automatic control of rotary

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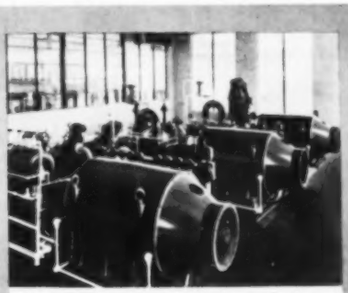

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rigs, and the use of portable electric rigs. Devices such as the flying magnetometer enabled such inaccessible regions as jungles, oceans, and mountains to be measured for magnetic studies. From 1937 to 1942, one out of every six wildcat wells drilled on technical information resulted in the discovery of an oil field.[124] Thus, the scientific progress made in exploration and drilling techniques did much to remove the large risks previously associated with oil exploration and development.

In addition to production technology, conservation laws and maximum recovery methods helped to curtail wasteful practices. Secondary recovery, which involves the removal of oil from a field where the natural reservoir pressure has been diminished, was usually accomplished by displacement methods. The three processes used were (1) the dissolved-gas drive—the expansion of gas released from solution in the oil; (2) the gas-cap drive—the displacement of the oil from the sand by the downward expansion of a free gas cap; (3) the water drive—the upward displacement of the oil by the influx of water from below the sand. The method used depends upon the type of pressure present in a particular field.

By slowing down the rate of oil production and through secondary-recovery methods, yields of oil fields have been greatly increased. For example, the East Texas field, which was discovered in 1930 and represented the largest oil discovery made in the United States, went to water soon after its discovery. However, through the use of the water drive, as well as a limited rate of removal, the estimated reserves of the East Texas field increased to three billion barrels from two billion after two billion barrels had already been taken from the field.[125]

Refining: In 1945, American refineries processed 774 million barrels of gasoline, 50 million barrels more than the previous year.[126] Approximately 5,000 byproducts from crude petroleum were made, and improvements in catalytic cracking led to the development of 100-octane gasoline for planes.

The "in-line" system of refining was preferred during the '40's. In this process, refining equipment was located and arranged in parallel rows. Pipelines were carried on supports above the central road, and along the sides of this road were the pumps whose suction and discharge lines dropped down from the pipe bank overhead.

In the "in-line" system, process buildings are relatively few and small in size, thus increasing plant safety. Access roads to the equipment provide an additional element of safety because they separate the various facilities and provide an easy approach for fire-fighting apparatus. In addition, large tank storage is almost always kept remote from the process area.

Batching was decreased as each process was integrated—although individually operated—into the overall production framework. Pneumatic control devices, which required a great deal of plumbing and installation cost, slowly gave way to electronic controls which involved a 50% saving in installation expenses.

Naphtha isomerization was introduced in the latter part of 1941. Using a catalytic process, ordinary naphthas were converted into a high-quality aviation-base stock for blending with synthetics to make 100-octane gasoline.

Hydroforming, another new method used in refining, yielded a more compact chemical unit which made higher octanes possible. Fluid coking increased output 20% by pumping oil residues into a deep bed of hot coke particles. Thus, lighter hydrocarbons were vaporized and cracked to yield both gasoline and fuel for home heating.

Much of the progress made in refining from 1940 to 1950 was due to the effort expended by the industry to meet wartime requirements. Consequently, many new processes and higher-quality petroleum products were available to the consumer and business sectors of the economy once the war ended.

Of the 369 refineries in the United States in 1948, half were located in the Southwest. The Texas-Louisiana Gulf Coast region was the site of eight major refineries—each with a daily capacity of 100,000 or more barrels.[127] Each refinery was the focal point of railroads and pipelines which supplied sizable quantities of crude storage tanks for processing. Ocean-going tankers and canal barges were often used to carry the refined products to domestic and foreign markets.

Transportation: The harassment of German U-boats to coastal shipping during World War II presented a serious threat to tankers and barges transporting oil. From February to May 1942, 50 American tankers were sunk and, as a consequence, inventories in the East declined rapidly. A severe winter in 1941-42 made this situation even more serious.

Some of the steps taken to remedy this condition were short and long run programming made by the Petroleum Administration for War and by other government-industry groups; the use of substitute transportation where possible; the rearranging and building of new essential facilities; and curtailing and rationing civilian consumption.

In the beginning of 1941, there were about 127,000 miles of oil pipelines in the United States.[128] Of this total, 63,000 miles represented crude-oil trunk lines; 9,000 miles were product lines; and there were 55,000 miles of gathering lines.

Although many new lines were constructed during the war, two stand out as especially significant. Completed on August 14, 1943, the Big Inch pipeline extended from Longview, Texas, to Phoenixville, Pa. This pipeline delivered approximately 300,000 bbl of oil per day at the East Coast terminal.[139] It was 1,254 miles long and had 25 electrically operated pumps at 50-mile intervals. Built under government sponsorship, the Big Inch was operated by the War Emergency Pipe Lines—a nonprofit industry corporation made up of 11 eastern companies.

In March 1944, the Little Big Inch, with a line 1,475 miles long, was completed. It was so named because its diameter was 20 in. as compared with the 24-in.-diameter pipe of the Big Inch. Together, these two lines carried about two-thirds of all oil which arrived at the East Coast.[140]

All in all, the government and the oil industry undertook 35 pipeline projects valued at $334 million during the war.[141] Of this total, the industry provided about $180 million, and the remainder was

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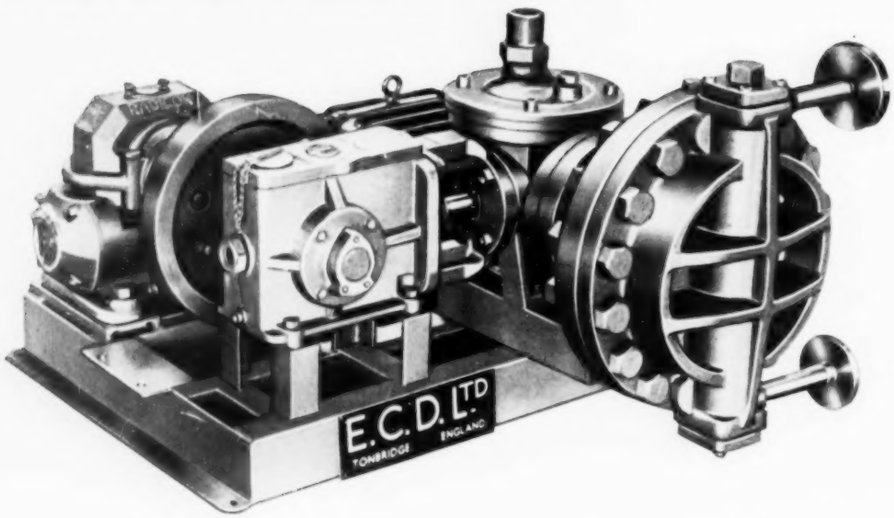

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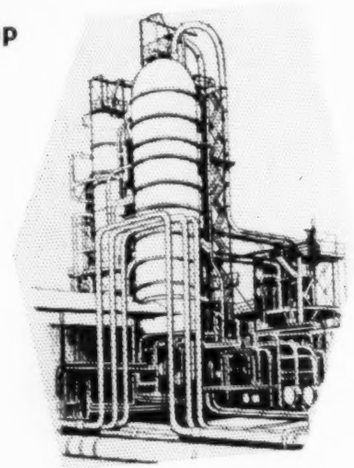

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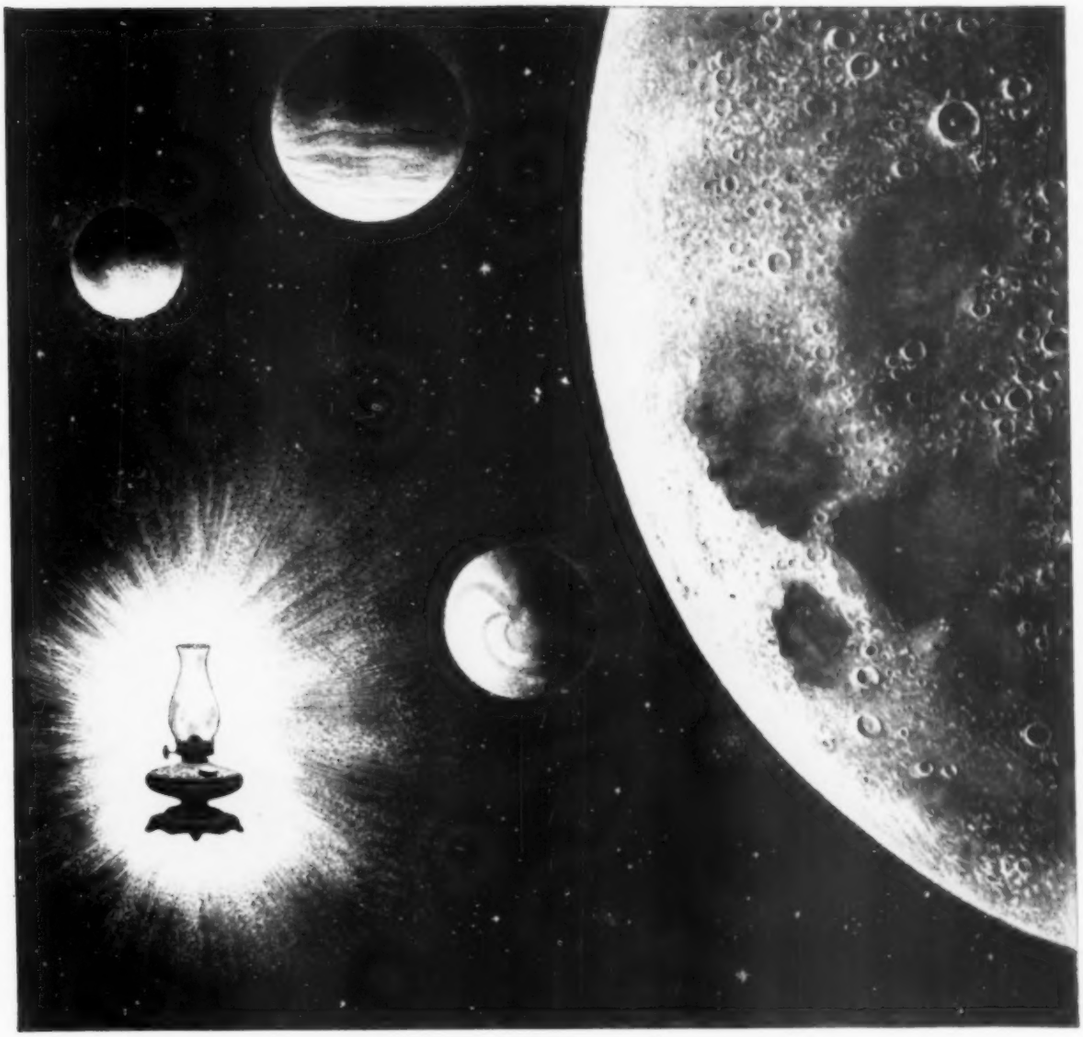

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supplied by the government. Activity in this field continued even after the war and, in 1949, there were 60,560 miles of gathering lines and 71,373 miles of crude trunk lines in the nation.[142]

The tanker, although restricted by German submarines, nevertheless played an important part in the war effort. By 1940, we had a fleet of 383 tankers ranging in capacity from 25,000 bbl to 150,000 bbl.[143] Tankship and barge transportation was especially active on the Great Lakes, the New York State Barge Canal, and the Hudson River. Petroleum barges numbered 1,400 in 1940.[144]

Trucks and rail tank cars were called upon to take up the slack caused by the restricted use of tankers. Round-the-clock use of trucks, more efficient routing of deliveries, and the zoning of demand areas to eliminate back hauls and cross hauls —all served to increase the capacity of tank trucks. Restrictive state and local laws were relaxed to allow maximum truck oil transport. It has been estimated that the use of trucks released a minimum of 25,000 railway tank cars for East Coast and other long-distance service.[145]

After the war, shippers realized that tank trucks deserved a larger role in the short-haul movement of oil because (1) faster delivery and return required less inventory and storage capacity than would otherwise be needed; (2) trucks enabled deliveries to be made directly to service stations and large consumers and, therefore, eliminated the double handling caused by using bulk plants; (3) trucks provided for greater flexibility because deliveries were made when needed, and did not depend on train schedules.

Railway tank cars, although declining in importance prior to 1940, became extremely vital during the war. The 145,000 railroad tank cars available in 1940 contributed greatly in supplying the oil needs of the country and, by 1944, shipments reached 100,000 b/d on the railroads.

The war enabled great progress to be made in the transportation and distribution of petroleum. As a result, this segment of the industry, along with the others, became more efficient than it had previously been.

Marketing: The war brought about many changes in marketing also. The marketer, accustomed to expanding his outlet sales, found it difficult to accept limited deliveries to his station. Gas rationing was begun in 1942, and it included restriction on pleasure driving and speed limits. Lubricating oils and greases were not rationed, but a severe shortage of rubber tires added greatly to the problems facing the marketer. Similarly, customers using heating oil and residual fuel oil were encouraged to convert to the use of other energy fuels.

Problems of pricing also arose during this period. For example, in order to conserve the supply of tetraethyl lead, the Petroleum Administration for War directed the industry to reduce the octane rating of regular-grade gasoline. Due to this reduction in quality, the OPA ordered a price reduction of ⅛ cent per gallon.

Following the war, the oil industry was confronted with a tremendously expanded peacetime market. Oil heating for home use, gasoline for automobiles, and oil for industrial uses—all raised demand to record highs. At the same time, we were called upon to supply petroleum to the war-destroyed countries of Europe. Thus, activity was greatly stimulated within the industry to meet these demands. By 1948, there were 188,253 service stations in the United States.[146]

An even more significant result of this increased demand was the fact that the United States became a net importer of crude oil in 1948 for the first time in 26 years. The greatest supplier of crude from abroad was Venezuela which exported 101,824,870 bbl to the USA in 1949.[147] This shift in balance of petroleum trade signaled a tremendous increase in foreign activity by American oil companies—particularly in the Middle East and in South America.

Natural gas continued to gain in importance after the war. Increases in the price of fuel and bituminous coal made natural gas the cheapest fuel on the market.[148] In January 1950, the USA supplied half its total energy requirements through petroleum and natural gas. With only 32% of the world's proved oil reserves, it was consuming close to two-thirds of the free world's oil production.

Summary: World War II placed great demands on the oil industry and, through its efforts in meeting this demand, the industry was able to make considerable progress in every phase of its operations. However, the consumption of large quantities of petroleum during the war, plus a severe winter in 1947-48 gave rise to fears that our domestic industry would soon be unable to meet completely the needs of a growing economy.

Many hearings were held in Washington in 1945 by the Senate's Special Committee to Investigate Petroleum Resources. Finally, in 1946, OPA price controls were removed to stimulate new exploration and development activity in the industry.

On January 13, 1949, the National Petroleum Council issued "A National Oil Policy for the United States." This report stressed the need for a strong and healthy domestic oil industry, but also recognized the need for development of foreign oil sources. It warned, however, that oil imports in excess of our needs would serve only to retard domestic exploration and development of new oil fields. The problem of oil imports was to become even more difficult in the next decade.

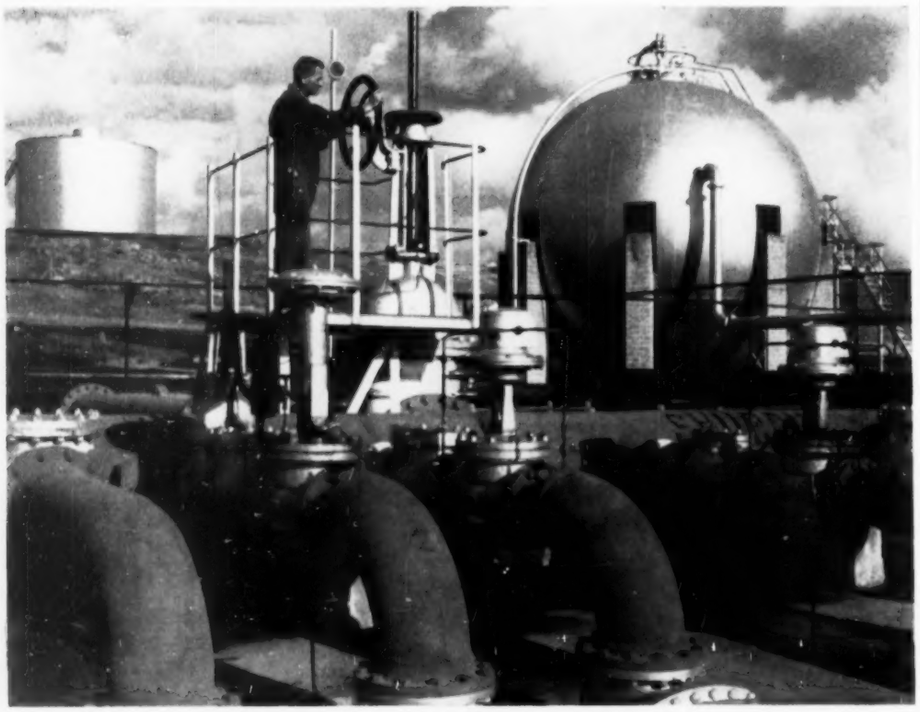
Another problem faced by the oil industry concerned the offshore reserves of the Gulf Coast. When Secretary of the Interior Krug told a Senate-House committee that the continental shelf contained about 100 billion barrels of oil, the controversy over the title to property of these submerged lands began. Whether the state or the federal gov-

TABLE VII
USA CRUDE PRODUCTION, 1940-1950
(Thousands of Barrels)

1940	1,353,214	1946	1,733,939
1941	1,402,228	1947	1,856,987
1942	1,386,645	1948	2,020,185
1943	1,505,613	1949	1,841,940
1944	1,677,904	1950	1,973,574
1945	1,713,655		

Source: *Petroleum Facts and Figures*, New York, API, 1950, p. 147; 1956 edition, p. 350-51.

CONTRACTORS TO THE OIL INDUSTRY



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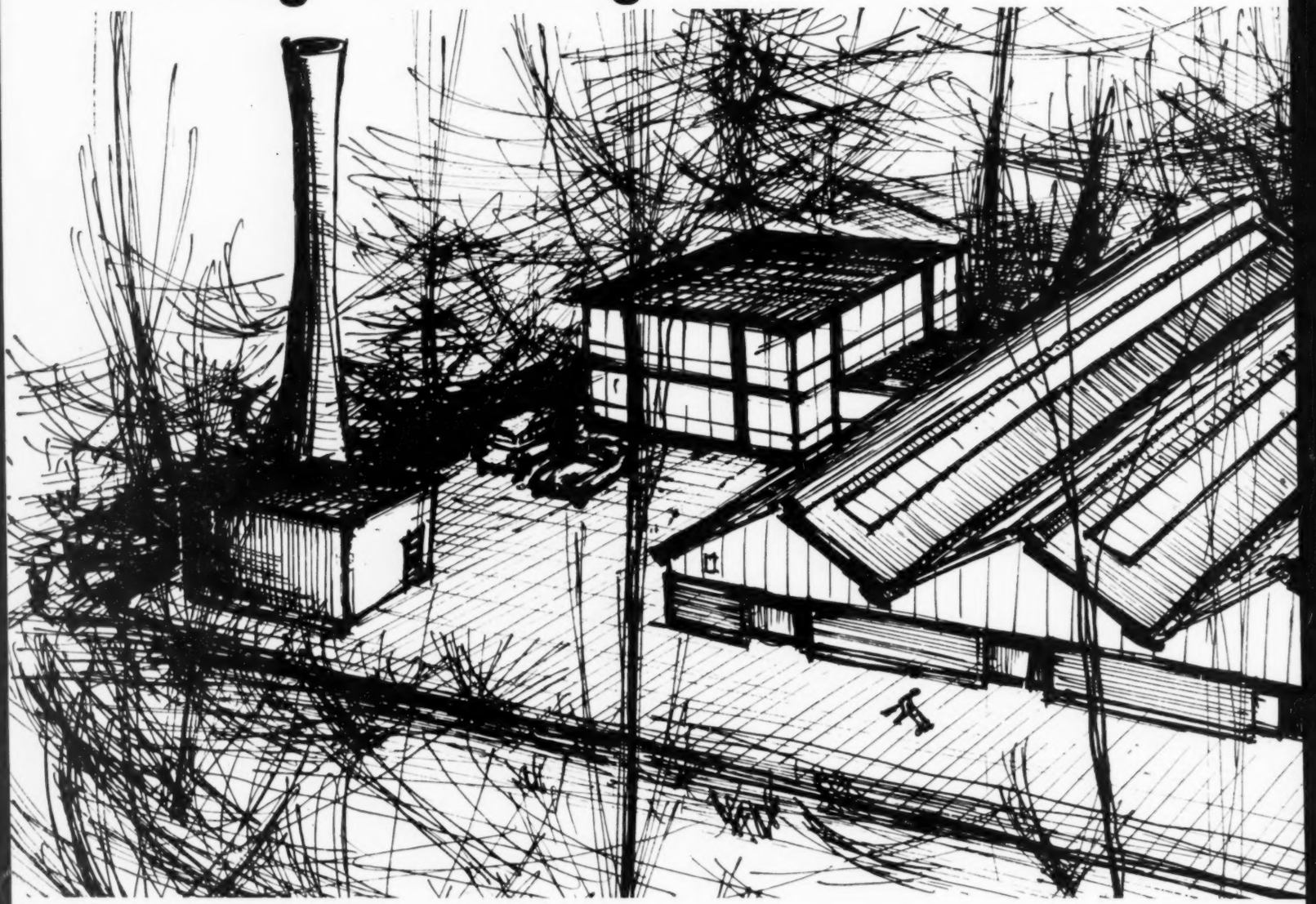

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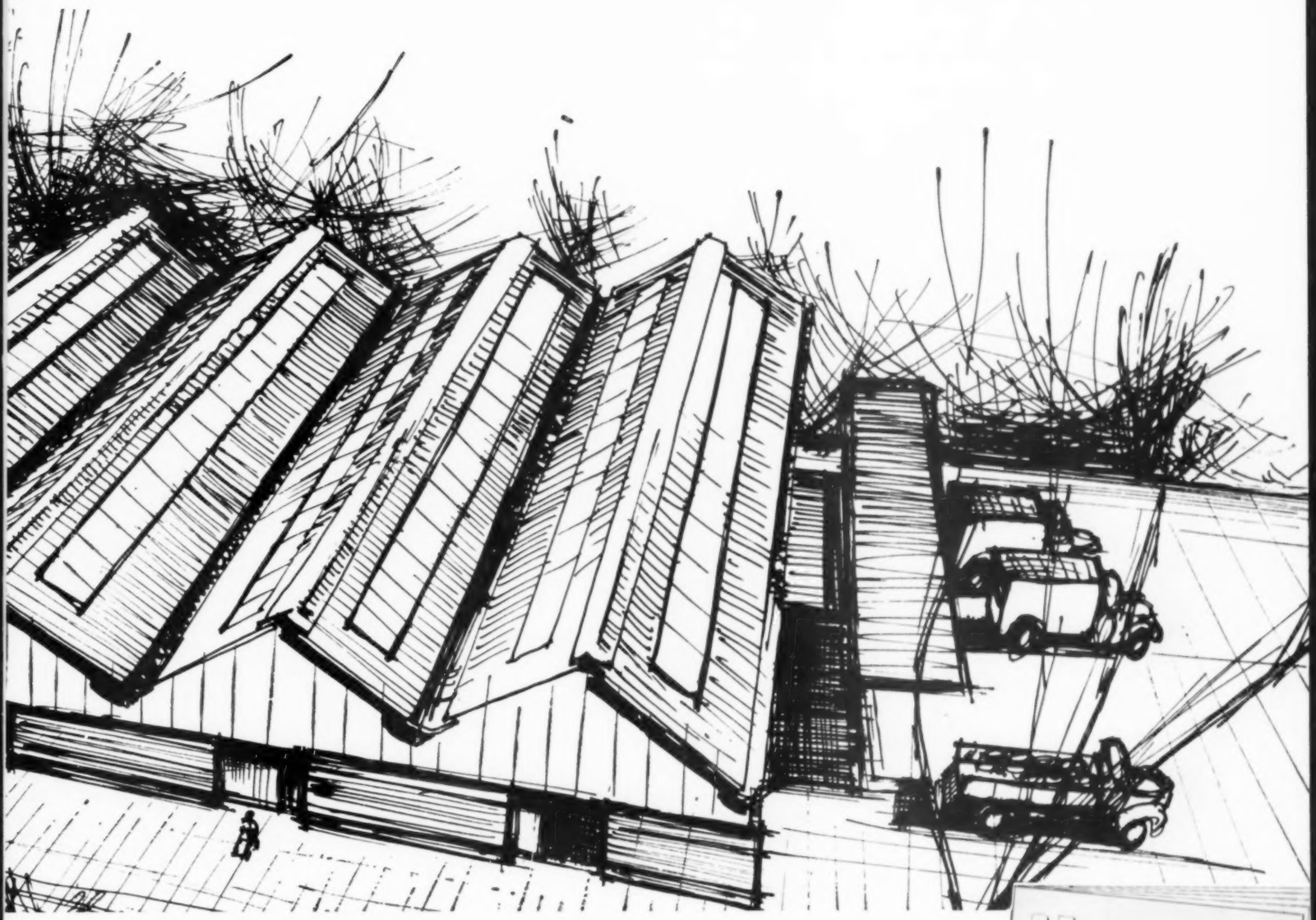

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ernment owned the land outside the three-mile limit presented great difficulties to oil men and politicians alike.

Hence, while the industry found itself in a growing market after the war, it was also faced with two serious problems which were to cause much disagreement within the country and within the industry itself.

1950-1959

Since the year 1959 marks the 100th anniversary of the American oil industry, this chapter will be primarily devoted to an evaluation of its growth. Further, because the offshore and oil-import problems were important during the years 1950-1959, the progress made toward their solution will be mentioned. However, most of this chapter will summarize the present status of the oil industry in our country's economy.

Offshore Production: The major areas of interest at the present time are the offshore areas of the Gulf Coast and the Four Corners area in the West. This latter region is located at the intersection of the boundaries of Utah, Colorado, Arizona, and New Mexico. In addition, North and South Dakota became small oil producers in 1951 and 1954, respectively.

Since marine operations have become so important, it should be mentioned that there are three general methods of offshore drilling: (1) The self-contained permanent platform which is large enough to house personnel and to provide space for supply storage and drilling operations. Such an installation often costs more than a million dollars.[149] (2) A small platform and a floating tender (service craft). (3) A mobile platform, including a submersible barge. This latter method is often considered to be most economical because it is portable, and may be used to drill many wells. One of these, however, ranges in cost from $1½ to $4 million.

Total investment in offshore equipment in 1955 amounted to approximately $100 million, and the daily cost of operation per rig was $5,000.[150] While over 1 billion had been spent for exploration, drilling, and equipment in the tidelands by 1955, only about $200 million had been realized as a return on the investment.[151]

Most of the drilling has been done in water 60 ft deep or less. One well has been drilled 72 miles from shore, but the farthest producing well is 43 miles out from the coast.[152] From 1938 to 1955, a total of 905 offshore wells was completed, and there are now seven productive fields off the coast of Texas and 66 located off the coast of Louisiana. A daily production of 90,000 bbl of crude and condensate was achieved during the late 1950's.[153] While approximately 570 wells of 9,700 ft average depth were completed in 1957, it was forecast that 1,200 wells of 12,400 ft average depth would be completed in 1970.[154]

As previously stated, the problem of the ownership of offshore oil lands was causing great difficulty due to both state and federal claims. In 1953, the Submerged Lands Act was approved by Congress and the President. This law gave the gulf states all rights to minerals under adjoining seas to a distance of three miles from shore, or the state's historic boundaries—whichever was farther. Texas, Mississippi, Alabama, Louisiana, and Florida all contended that their boundaries were fixed at three marine leagues or more when they entered the Union. One marine league is equivalnt to 3.45 miles.

Then in 1958, the federal government, through the Department of Justice, reversed itself and brought suit to claim all rights to underseas oil beyond the three-mile mark—the measure of national sovereignty. The central point of the government suit is that state boundaries cannot extend beyond national boundaries. Moreover, it charges that, if the states were allowed to retain the limits they had before entering the Union, it would mean that they had annexed the United States, and not the reverse. The central point of argument presented by the states is the promise of President Eisenhower and the 1953 law recognizing their old boundaries. In addition, they draw a distinction between claims to an area for mineral rights and claims to sovereign rights. Since litigation is still in progress, the funds obtained as royalty payments from the areas under dispute are being held in escrow. A Supreme Court ruling on the dispute is expected soon.

Oil Imports: The Suez crisis caused USA production to reach a record level of 7,717,000 b/d in March 1957. Following the crisis, production declined due to a slackening in the domestic demand for oil. As the allowable rate of production was decreased steadily from August on, the oil-import controversy became more pronounced. Domestic producers insisted on a restriction of imports according to the security clause contained in the Trade Agreements Extension Act of 1955. This act empowers the President to restrict the importation of any product or material which threatens to impair the stability of a domestic industry. The domestic oil producers argued that excessive oil imports were replacing domestic petroleum on the USA market and contributing to the problem of oversupply. They claimed that a reduced market and restricted production hindered their incentive and ability to continue the search and development for new domestic resources. Such a condition, they felt, would greatly harm our national security.

The oil-import limitation policy actually began on February 26, 1955, when the President approved the findings of the Cabinet Committee on Energy Supplies and Resources that rising imports were a threat to domestic production. The government then requested that imports be held voluntarily at the same ratio to domestic production that they had in 1954. This plan worked reasonably well until March 1957, when the Committee to Investigate Crude-Oil Imports found that planned imports for that year would rise to 16% of domestic production as compared with 11.3% in 1954. Consequently, new voluntary restrictions were imposed to cut back imports by 10%—using the average of the years 1954 to 1956 as a base. New importers were asked to maintain their present levels. Originally, the five

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states on the West Coast were exempted from this ruling; but, in December 1957, they too were included, and oil imports were again subjected to an additional percentage cutback.

The problem concerning oil imports is indeed a difficult one, with many justifiable arguments on both sides of the controversy. It is not the purpose of this paper to discuss the problem completely. However, it is important to note that the situation presents a serious problem to the industry. It concerns not only immediate national security, but the whole problem of future reserves. In other words, what reliance will we have to place on foreign oil in the future? Thus the issue concerns the maintenance of available supplies to an economy which is greatly dependent upon petroleum for its operation and growth. For, although the United States for many years led the world in oil production, its position has steadily declined. The domestic industry is still growing, but it is losing its place relatively as the oil industry outside USA borders grows faster.

The United States has about 15% of the free world's proved oil reserves; yet it consumes about 50% of the total free world's production. The Middle East, however, consumes only 2% of the world's oil; yet it has approximately 70% of the free world's proved reserves. Because of this proportion, the drilling-up of domestic prospects and the increased difficulty and expense of finding more oil in this country have helped to provide a stimulus for foreign-oil activity by many American companies. Domestic producers, however, feel that a strong domestic industry is capable of finding new domestic sources and supplying our future needs. These producers are opposed only to excessive and, therefore, harmful oil imports; they are not opposed to oil imports as such.

Production Summary: Between 1859 and 1957, 1,716,654 wells were drilled in the United States. Of this total, 1,017,046 were oil wells; 122,088 were gas wells; 453,329 represented dry holes; and 34,191 were service wells used to inject water or gas into the ground in order to increase the pressure needed to remove the petroleum.[155]

Of all the wells drilled in the United States since 1859, 26% have been dry. In addition, only one out of 12 wildcats currently drilled in a new field is a producing well.[156] In 1957, 54,017 wells were drilled. Of this total, 28,272 were oil producers, 3,917 were gas, 20,762 were dry, and 1,066 were service wells.[157]

Refining: One of the most significant breakthroughs in oil-refinery processing was announced at the close of the ninth decade, and came to full flower within the past 10 years. This was the application of platinum to catalytic processing. First was the Platforming process announced in 1949 by Universal Oil Products Co., of which a small commercial unit was put onstream at the end of that year. Platforming was followed quickly by other competing processes for reforming of low-octane naphthas. Refiners have adopted the process so quickly that, within a decade after first announcement, virtually every refinery in the country had one or more units in operation.

In catalytic reforming with a platinum catalyst, naphthenes are dehydrogenated to produce aromatics such as benzene, toluene, and naphthenes as a principal reaction. There are others of lesser importance. Byproduct hydrogen from the process has created another processing step in the modern refinery for sulfur removal from light and intermediate distillates.

Near the close of the tenth decade, the World War II alkylation process was being adopted at a rapid pace for motor-fuel improvement. During the war, it had been employed to produce avgas. Catalytic cracking enabled refineries to get increasingly more gasoline from each barrel of crude. By 1955, the composite yield of products from a barrel of crude had changed radically from what it had been in 1918.

If the methods of gasoline manufacture used in 1918 were employed today, gasoline prolution in 1955 would have failed to meet our needs by 26 billion gallons. Similarly, the quality of the 1918 product could never satisfy today's requirements. For example, better-quality fuel enables two gallons of today's gasoline to do the work which required three gallons in 1925.[158] Total USA refining capac.ty was 9,157,700 b d as of December 31, 1957.[159]

In the past 20 years, the petroleum industry has produced over 2,000 new petrochemical products.[160] Through research, it has also brought about three new industries: synthetic rubber, plastics, and the synthetic-fiber industries.

TABLE VIII

Yields From a Barrel of Oil

Gallons Per Barrel			% Yielded	
1918	1955		1918	1955
10.6	18.0	Gasoline	25.3	43.9
5.6	1.8	Kerosine	13.3	4.3
22.5	15.6	Gas Oil and Distillates, Residual Fuel Oil	53.5	37.3
3.3	6.2	Other Products and Losses	7.9	14.5
42.0	42.0		100.0	100.0

Source: *Facts About Oil*, New York, API, 1957, p. 15

Transportation: As of 1957, a network of 201,800 miles of pipelines carried crude oil and refined products throughout the United States.[161] The diameter of these lines ranged from 2 in. to 30 in.; and, in 1955, 758 million barrels of major refined products moved through the country's pipelines.[162]

Oil is kept moving through the lines at a speed of two to three miles per hour by pumping stations located about 60 miles apart. Recently, more and more of these stations have been electrically powered.

Transportation by tanker at present is divided into three categories: domestic, imports, and exports. The major movement is domestic for most of the American fleet operates in intercoastal trade. As of 1956, the United States tanker fleet numbered

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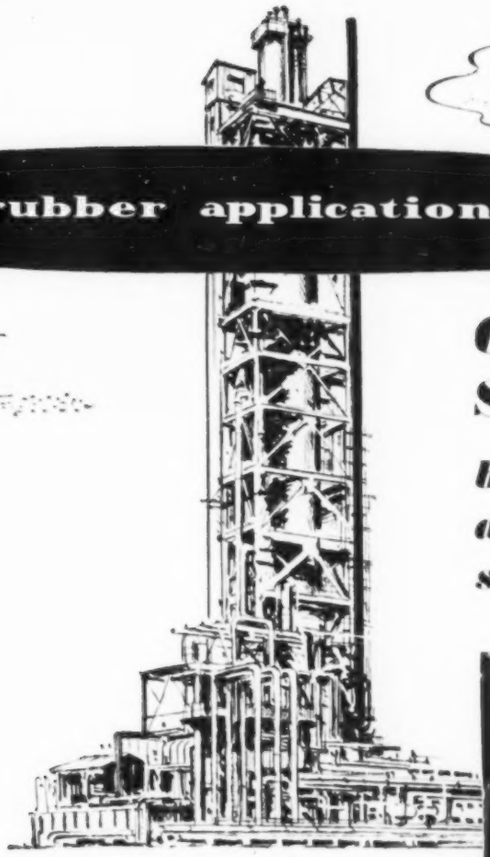

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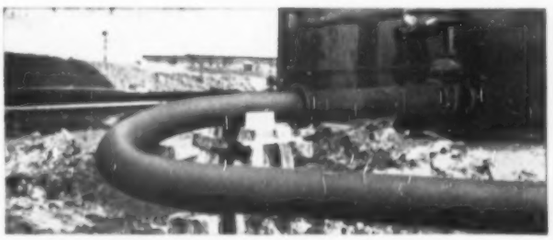

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490 vessels.[163] Of this number, 239 were owned by oil companies, 108 by nonoil companies, and 143 by the government. These ships comprised 19% of the total world fleet capacity. The United States tanker fleet, however, is much larger than this, for American shipowners place their vessels under foreign registry. These ships are either owned by USA nationals or by subsidiaries of domestic corporations; and, if we include them, we find that USA has a fleet of 823 vessels with 33.4% of the world's carrying capacity.[164]

Inland waterways have also played an important part in the growth of transportation facilities for the oil industry. During 1954, oil barges moved 120 million tons of crude oil and refined products over the rivers, lakes, and canals of our country.[165]

The transportation of oil by rail has not increased in proportion to the growth of the oil industry. Most of the crude and refined products transported by rail are hauled in tank cars which may have heating coils or insulation to protect the cargo from heat or cold. For example, asphalt requires heat to keep it somewhat liquid. These cars average in capacity from 8,000 to 10,000 gallons each. In 1956, there were 119,654 petroleum tank cars in use.[166]

Finally, there is at present a fleet of over 80,000 tank trucks in operation which are especially important for transporting products to local bulk stations, service stations, and to consumers.[167]

Marketing: The great growth in the demand for crude oil and its products may be evidenced from Table IX.

Petroleum and natural gas are the principal sources of energy in the United States. In 1955, oil accounted for 41.2% and natural gas for 25.5% of our total energy requirements.[168] The amount of energy supplied by these two sources has increased greatly in the years after World War II, as may be seen from Table X.

There were 27,078 companies engaged in bulk-plant operations or "wholesale distribution" in 1957.[169] As we have seen earlier, their customers include service stations, commercial consumers, public utilities, transportation companies, and factories.

TABLE IX

Growth in Products Using Petroleum

	1946 (Barrels)	1945 (Barrels)
Passenger cars	28,213,000	52,173,000
Trucks	5,986,000	10,332,000
Buses	174,000	255,249
Home oil burners	2,821,000	8,255,000
Farm tractors	2,560,000	4,800,000
Diesel-electric locomotives	4,441	23,531
Space heaters	5,167,000	9,000,000
Commercial aircraft	821	1,359
Military needs	60,000,000	212,240,000

Source: *Facts About Oil*, New York, API, 1957, p. 21. These are the latest figures available.

TABLE X

Sources of Energy Supply in the United States

(Quadrillions of Btu's)

	1946	1956
Water power	1.4	1.8
Coal	14.5	12.0
Natural gas	4.1	9.9
Petroleum	10.5	18.4
Total energy	30.5	42.1

Source: *World Petroleum Report*, New York, Mona Palmer Publishing Co., January 15, 1958, p. 64

TABLE XI

USA Crude Production, 1950-1957

(Thousands of Barrels)

1950	1,973,574	1954	2,316,323
1951	2,247,711	1955	2,484,423
1952	2,289,836	1956	2,617,432
1953	2,357,082	1957	2,617,800
		1958	2,448,837

Source: *Petroleum Facts and Figures*, New York, API, 1956, p. 350-51; 1957 and 1958 figures, API.

Retail distribution, of course, is carried on by the service stations. There were 181,747 such stations operating in the United States in 1954.[170] Those privately owned accounted for 95% of the total.

The volume of service-station activity has risen over the years until total sales amounted to $15.1 billion in 1957.[171] Consumer expenditures for gasoline and motor oils alone exceeded $7 billion for the same year.

Another retail distributor of petroleum products is the fuel-oil dealer who often maintains no storage facilities of his own. Instead, he is supplied by a bulk plant and sells directly to the consumer. However, some Fuel-oil dealers do maintain their own bulk plants.

Summary: As the United States oil industry reaches its 100th anniversary in 1959, it has come to encompass half of the world's oil industry. In terms of assets, it is one of the industrial giants of the nation; for, among the 30 largest corporations in the country during 1957, petroleum companies held 45.4% of the total assets.[172]

Over 1,650,000 workers are now employed by the industry.[173] Approximately 312,000 work in the production sector; 201,300 are employed in the refining phase; while 129,000 workers are engaged in transportation and distribution. At least one million employees serve in marketing and relating activities.

There are presently more than 42,000 businesses engaged in the production, refining, transportation, and wholesale distribution of petroleum and its products.[174] A breakdown of this figure indicates the following distribution:

Crude petroleum and natural-gas production	12,010
Petroleum refining	270
Lubricating oil and greases not made in refineries	243
Pipeline companies	54
Tankship companies	42
Bargeline companies	174
For-hire carriers, tank trucks	1,063
Petroleum bulk stations, terminals	14,047
Fuel-oil dealers	11,127
LP Gas companies with one or more bulk plants	3,000
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We have already mentioned the fact that there are more than 181,747 service stations in operation. Moreover, it is estimated that the total gross assets employed in the petroleum industry amounted to $50.7 billion by 1956.[175]

The growth of the American oil industry in the 100 years from 1859 to 1959 can only be described as "phenomenal." It is now one of the vital and basic industries in the United States, and its growth is a reflection of the growth of the entire economy. Not only has petroleum made many new products available to the market, but the growth and contribution of other industries—such as steel, the automobile, aircraft, etc., have all expanded petroleum's position on the market. Hence, in noting the progress made by one industry, we similarly acknowledge the progress and contribution made by very many others.

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(Continued on page 218)

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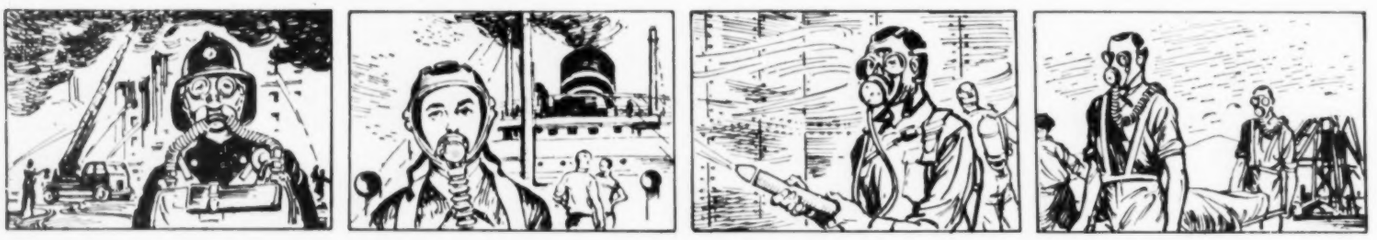

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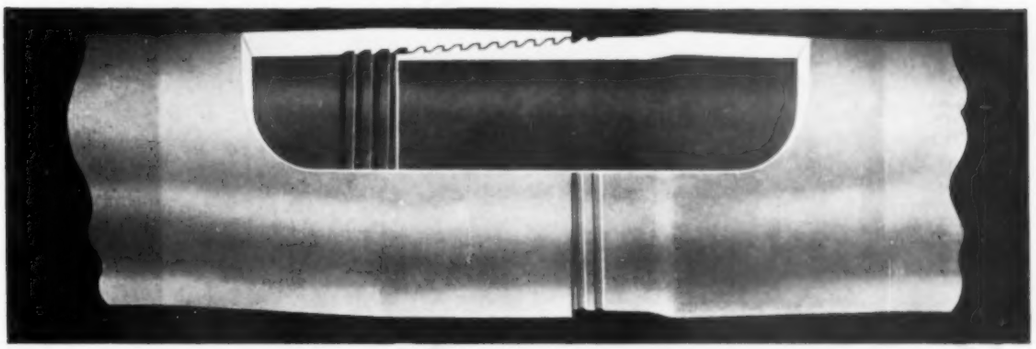

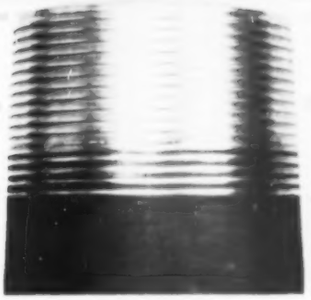

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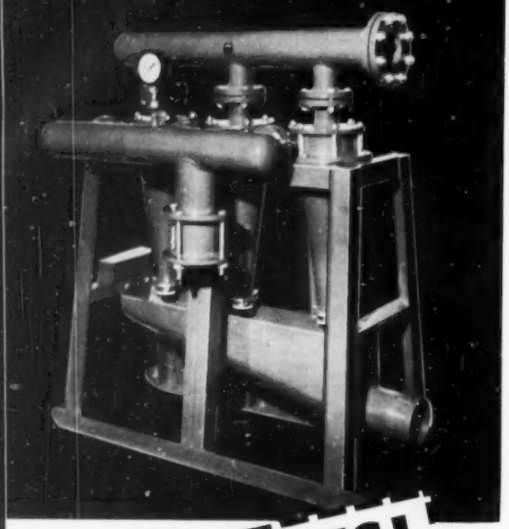

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[132] American Petroleum Institute.
[133] Fanning, *op. cit.*, p. 99-100.
[134] *Ibid.*, p. 104-5.
[135] *Ibid.*, p. 132.
[136] Rister, *op. cit.*, p. 383.
[137] Rister, *op. cit.*, p. 386.
[138] J. W. Frey and H. Chandler Ide (editors), *A History of the Petroleum Administration for War, 1941-45*, Washington, D.C., Government Printing Office, 1946, p. 89.
[139] William T. Hogan, SJ, *The Development of American Heavy Industry in the 20th Century*, New York, Fordham University, 1954, p. 168.
[140] *Ibid.*, p. 169.
[141] Frey and Ide, *op. cit.*, p. 101-109.
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[143] *Petroleum Almanac*, *op. cit.*, p. 64.
[144] Frey and Ide, *op. cit.*, p. 90.
[145] *Ibid.*, p. 97.
[146] *Petroleum Facts and Figures*, *op. cit.*, 1950, p. 342.
[147] *Ibid.*, p. 339.
[148] Hogan, *op. cit.*, p. 194.
[149] *Facts About Oil*, *op. cit.*, 1957, p. 5.
[150] through [153] *Ibid.*
[154] *World Petroleum Report*, New York, Mona Palmer Publishing Co., Vol. IV, Jan. 15, 1958, p. 59.
[155] American Petroleum Institute.
[156] *Facts About Oil*, *op. cit.*, 1957, p. 6.
[157] American Petroleum Institute.
[158] *Facts About Oil*, *op. cit.*, 1957, p. 15.
[159] *World Petroleum Report*, *op. cit.*, p. 60.
[160] *New York Times*, Jan. 22, 1956, Financial Sect., p. 1.
[161] American Petroleum Institute.
[162] *Facts About Oil*, *op. cit.*, 1957, p. 10.
[163] through [165] *Ibid.*, p. 12.
[166] *Ibid.*, p. 13.
[167] *Ibid.*, p. 12 and 13.
[168] *Facts About Oil*, *op. cit.*, 1957, p. 21.
[169] American Petroleum Institute.
[170] *Facts About Oil*, *op. cit.*, 1957, p. 19.
[171] American Petroleum Institute.
[172] *Fortune*, July 1958, p. 132 (companies ranked according to total sales).
[173] *Facts About Oil*, *op. cit.*, 1957, p. 30.
[174] *Ibid.*
[175] *Facts About Oil*, *op. cit.*, 1957, p. 31.

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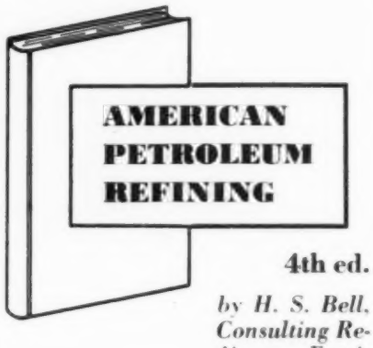

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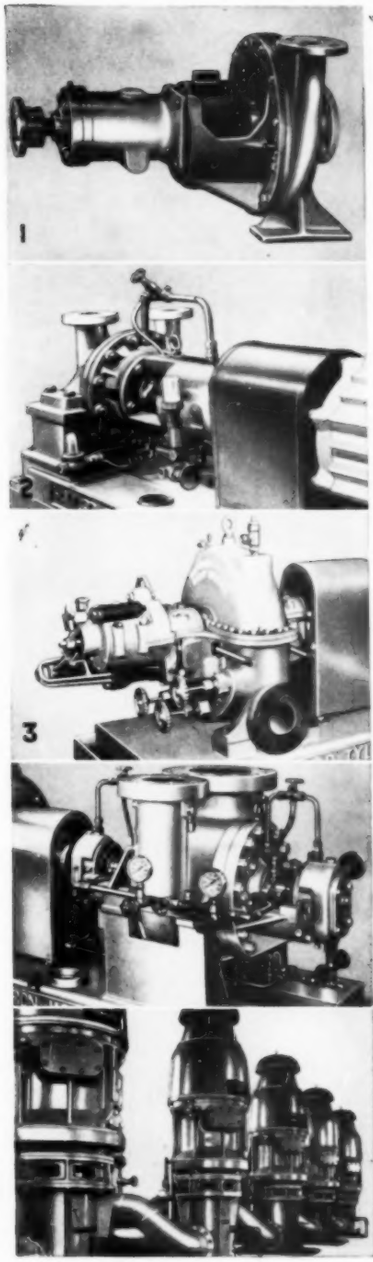

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THE FREE-PISTON ENGINE...

a new prime mover for easy operation and maintenance, which burns a wide range of fuels.

by Donald H. Robson*

ARTICLES have appeared in the world technical press during the past few years describing the mechanical layout and functioning of the Pescara-SEME-Muntz free-piston engine system. This ground will not be covered again. Intention here is to review some of the projects on hand in the UK where firm contracts have been placed for a free-piston plant for a variety of industrial purposes.

A free-piston power plant comprises a given number of free-piston gasifiers, the gas from which is piped or ducted to an expansion gas turbine which, in turn, may drive (with or without a gearbox) a pump, compressor, electric alternator, etc.

This report is concerned with the application of the GS.34 type of gasifier which has a rated output of 1,000 shp; therefore, the power output of sets using this gasifier will be in multiples of approximately 1,000 hp or, in the case of electrical plant, 750 kw.

Fig. 1 illustrates the mechanical layout of the GS.34 gasifier, while Fig. 2 is a diagrammatic cross-section.

The gas conditions and the characteristics of gas flow from any number of gasifiers varies very little; therefore, it is possible to design a range of turbines to match these standard conditions and to satisfy a wide range of applications.

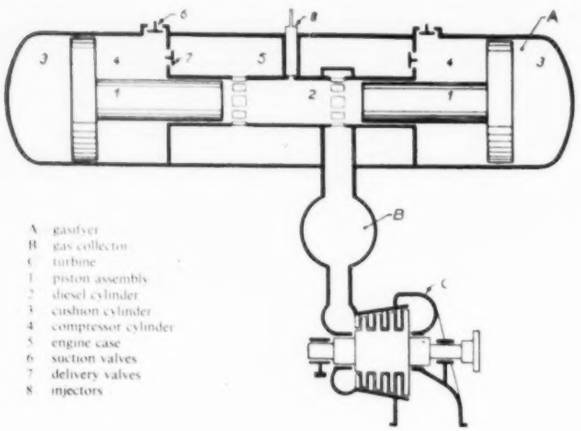
The National Gas and Oil Engine Co. Ltd. obtained a manufacturing license for the GS.34 gasifier in June 1956. Nine months later, the first production prototype was started on the test bed in the works. Now the factory holds orders for over 30 gasifiers for six contracts. About the time National obtained this gasifier license, the Brush Electric Engineering Co. Ltd. received an order from Kellogg International Corp., placed on behalf of Imperial Chemical Industries Ltd., for six expansion gas turbines for use with a gasifier installation to provide power for a chemical plant. These turbines have now all been tested and installed, and the plant is about to be commissioned.

Three National GS.34 gasifiers provide gas to drive the series-300 turbine which, in turn, drives a water brake through an Allen epicyclic reduction gearbox. In addition to the turbines designed and manufactured for this contract, Hawker Siddeley Brush Turbines Ltd. have designed a change of standard turbines up to 8,000-shp.

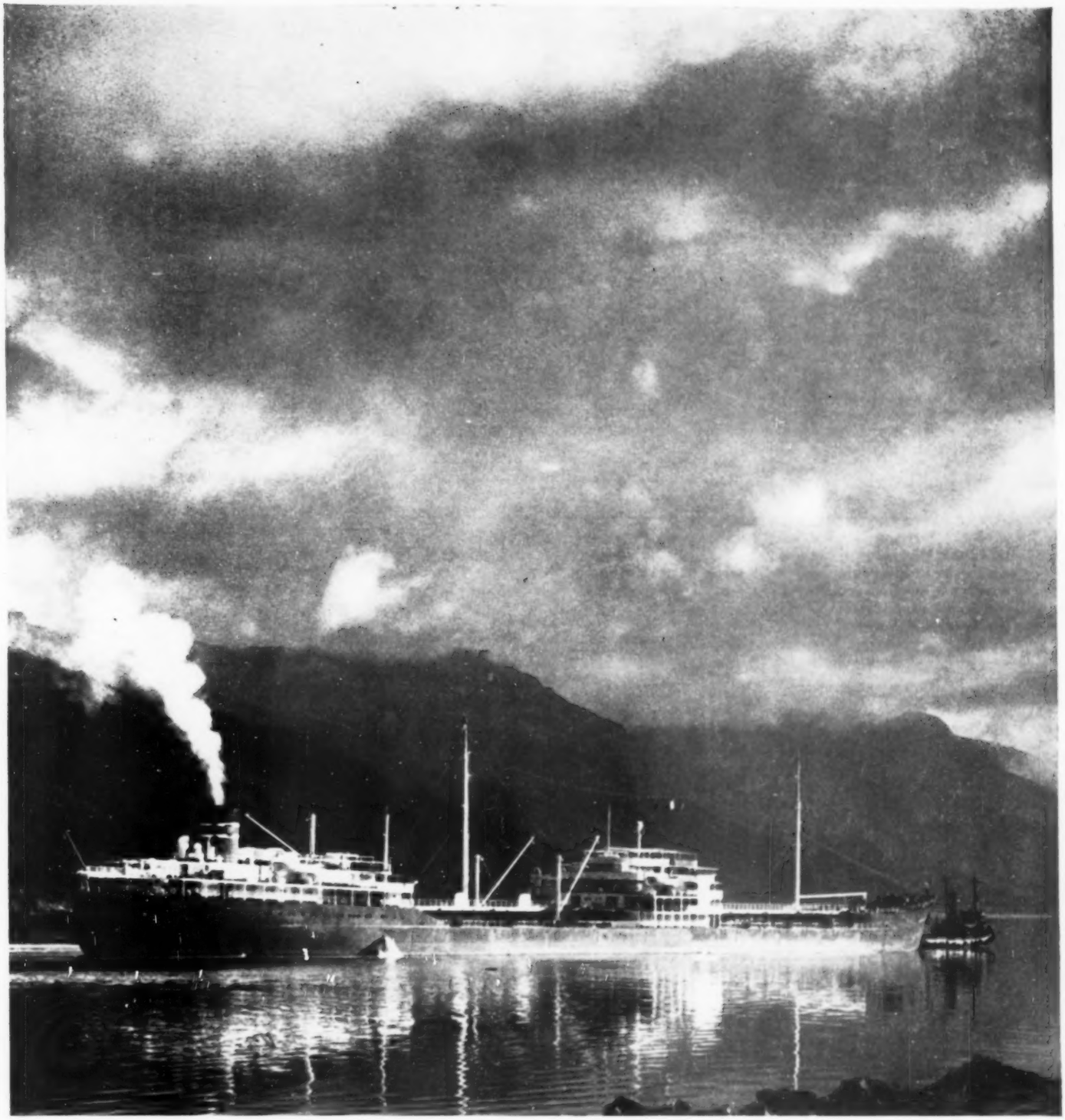
An attractive feature of the GS.34 gasifier is its ability to burn a wide range of fuels without significant modification. Thus a gasifier installation can always be run on the cheapest available fuel at any given site or locality.

In the autumn of this year, testing will begin of a 2,000-shp gasifier turbo-compressor set for the Zinc Corp. mine at Broken Hill, Australia. This set comprises three GS.34 gasifiers, one series-200 turbine, and an Oerlikon rotary air compressor of an output of 10,000 cfm at 100 psi. Since the plant will be operated on the

*London Director, National Free Piston Power Ltd.



Diagrammatic cross section of mechanical layout of GS.34 free-piston engine.



Loch Long, Scotland. A BP Tanker moves up towards The British Petroleum Company's Finnart Ocean Terminal, where a new jetty capable of accommodating the largest tankers foreseeable came into operation in November, 1958. BP builds now for an expanding future.

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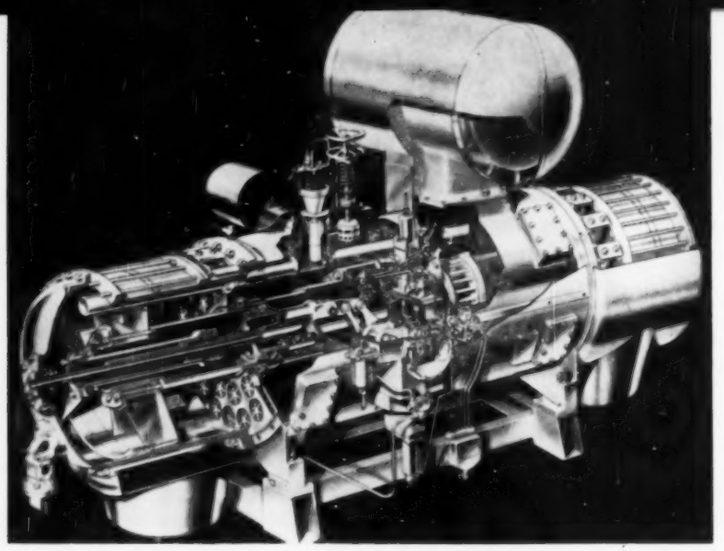


Sectional view of National GS.34 free-piston gasifier.

base load, a third gasifier is provided to enable the turbo-compressor to be operated continuously while permitting progressive maintenance to be carried out on the gasifiers. In this case, the turbine and compressor speed is matched, and no reduction gearbox is required.

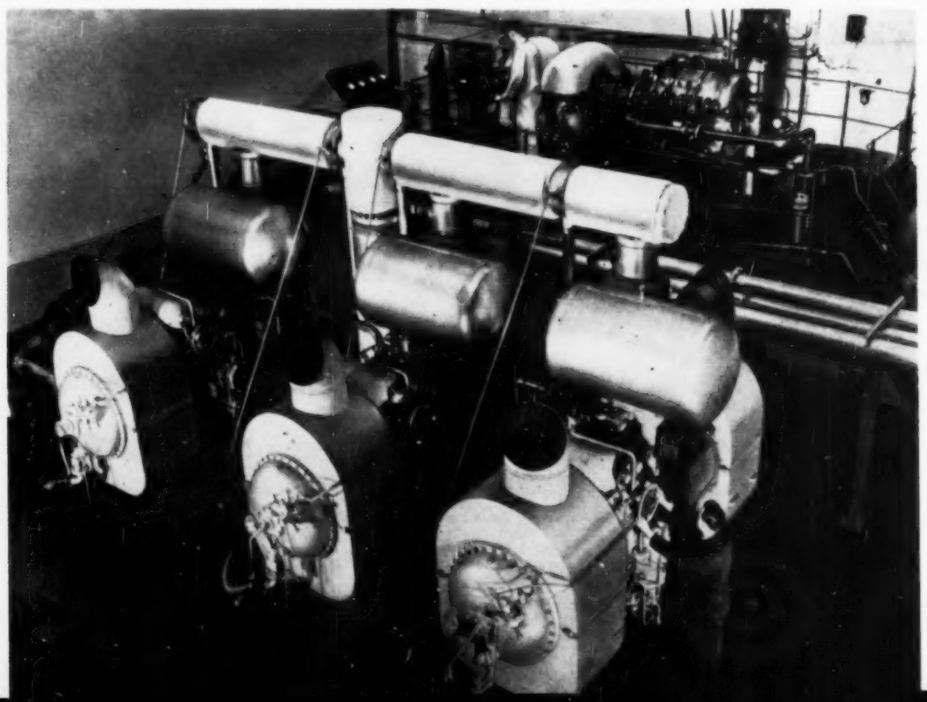
Another interesting contract on hand at the National and Brush works is for a pipeline pumping set for the Iraq Petroleum Co. The set will be installed early in 1960 on the IPC northern pipeline in Syria. The set comprises four GS.34 gasifiers, a series-300 turbine, and a Mather & Platt pump driven through an Allen epicyclic gearbox. As in the case of the air-compressing set, a standby gasifier is provided to enable maintenance to be carried out on the gasifiers without interference with its continuous running of the plant. This is the first application of the free-piston principle to pipeline pumping, and will be watched with great interest by the oil industry. The control and operation of the set will be largely automatic, and the gasifiers will be arranged to run on the oil being pumped in the line or on an independent supply.

In the field of electrical generation, work is in hand on three major power plants. One is a six-megawatt plant to provide for additional power at the existing steam and diesel-power station at Riihimaki in Finland. The present contract represents stage No. 1 of a plan to install two six-megawatt plants. Each set comprises eight GS.34 gasifiers driving a series-800 (8,000-shp) turbine direct-coupled to a Brush alternator. An interesting feature of the plant is that the gasifiers are to be installed in a two-story extension to the existing power station, the gas being ducted to the two turbo-alternators to be sited on the existing turbine floor. The scheme illustrates the flexibility of free-piston installations. Here the set will run on the cheapest fuel at present available in Finland with a Redwood No. 1 viscosity of 400 sec at 100 F.

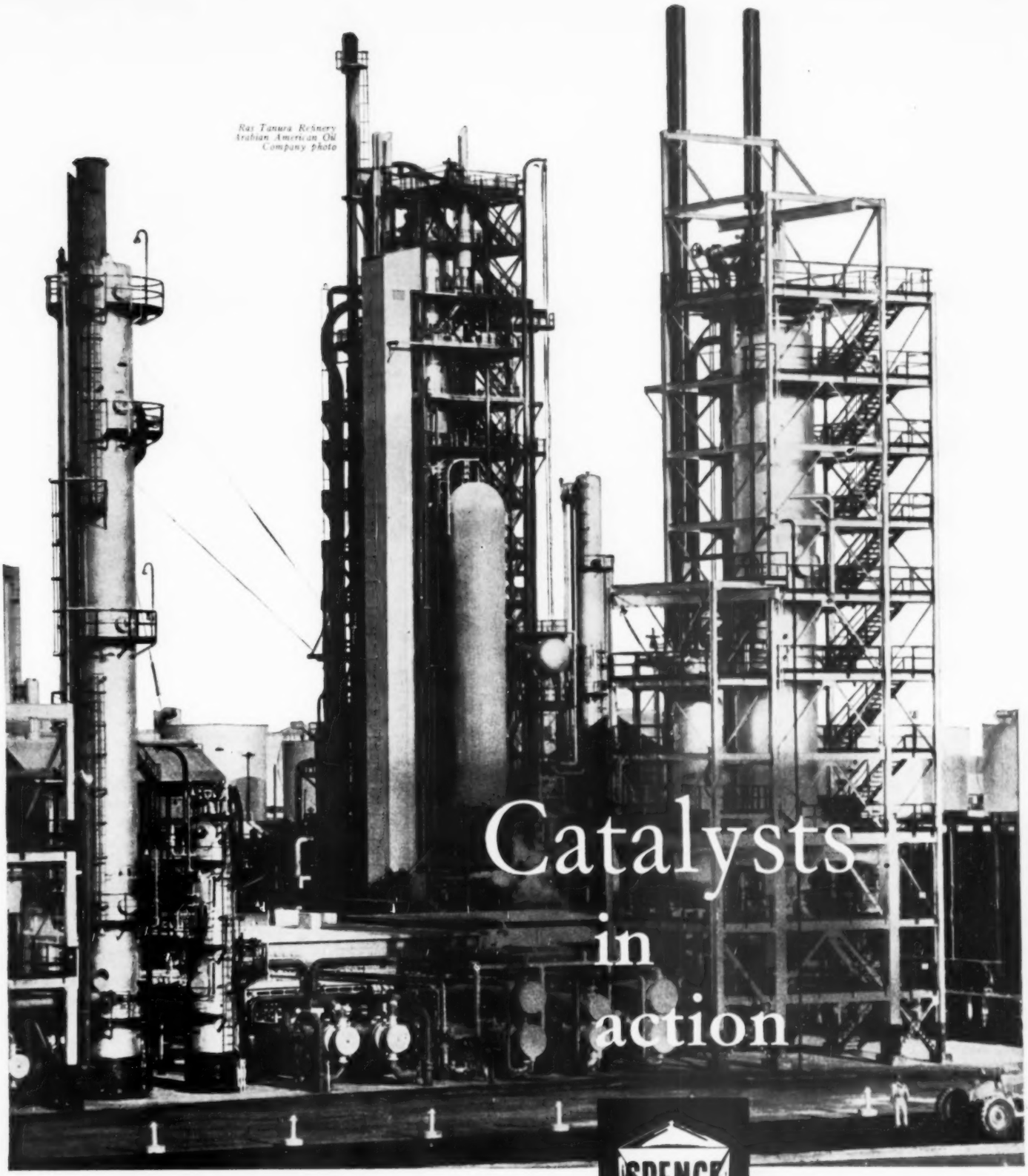
Generating plant is also under construction for the Central Electricity Board of the Federation of Malaya for extensions to the diesel station at Butterworth on the mainland opposite Penang. This installation comprises two 3-megawatt sets totaling eight GS.34 gasifiers driving two 4,000-shp 3-mw turbo-alternators through reduction gearing. The sets will be arranged to run independently to meet load requirements in the most efficient manner. Fuel to be used here will again be the cheapest at present available in the area, with a Redwood No. 1 viscosity rating of 600 sec at 100 F. An interesting feature is that the plant will be installed in one end of the existing building in an area of 80 ft by 66 ft, and under the existing crane rail with a hook height of 20 ft.

As a follow-on contract, Hawker Siddeley have secured a further order from the Central Electricity Board of Malaya for two 3-mw sets for installation in a new power station in southern Malaya.

The foregoing provides evidence that now the GS.34 free-piston gasifier is through its teething troubles as a fully developed, reliable prime mover; engineers all over the world are looking forward to putting this power system to work. In the power ranges between diesels and high-pressure and temperature steam plant, free pistons ar seen to offer attractive features, the most notable of which are: insensitivity to fuel, ease of installation, simplicity of operation and ease of maintenance, and the ease with which standby plant can be installed with resulting high reliability and flexibility of operation. END



A free-piston gasifier turbocompressor set on test at National Gas & Oil Engine Co. Ltd.



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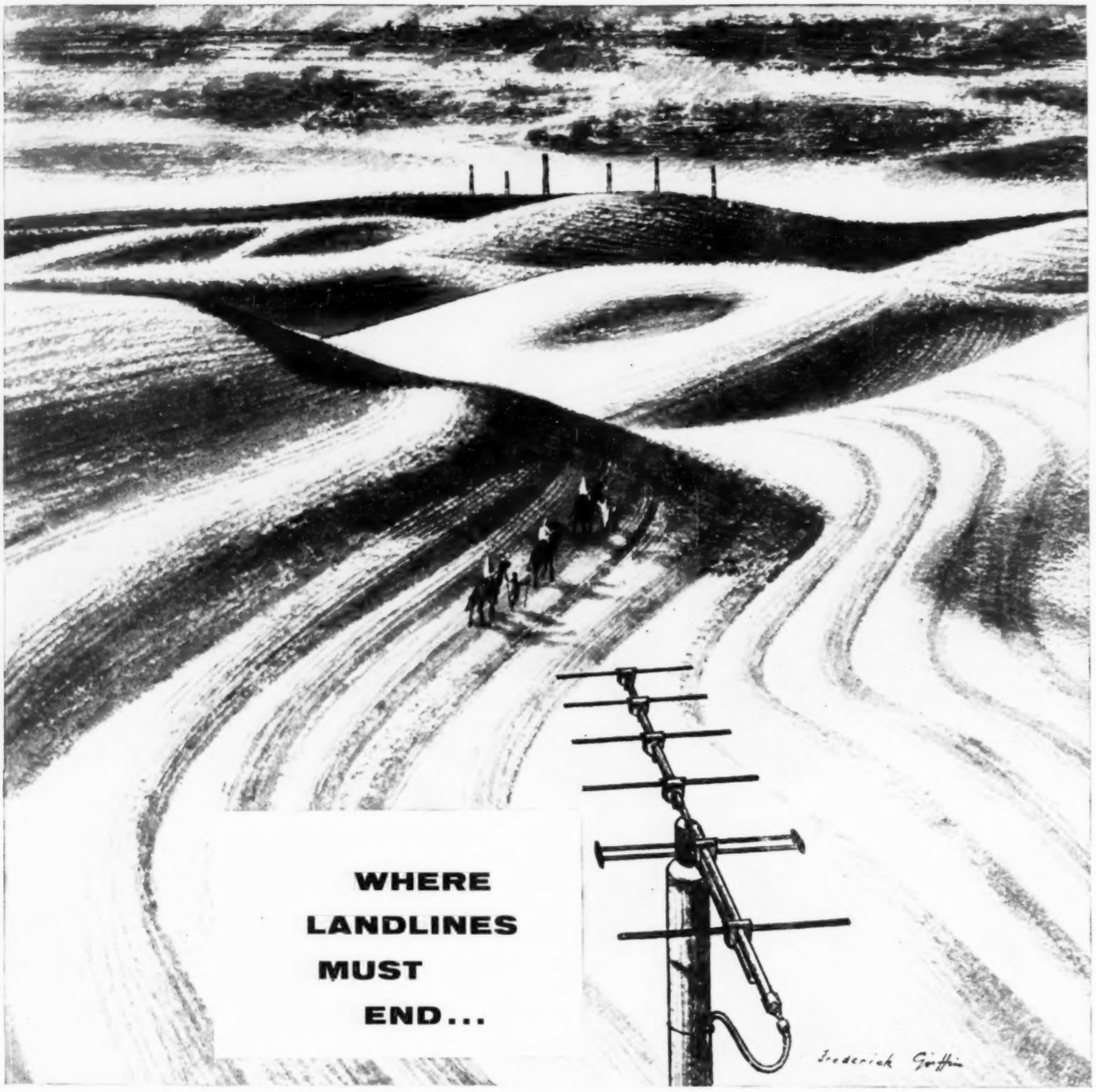

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Williams probably used this "spring-pole method" for drilling his wells.

101 Years of Canadian Oil

"CENTENNIAL" is by now an old word to Canadians. Their celebration of 100 years in the oil industry began June 28, 1958, with Canadian Oil's presentation to Oil Springs, Ontario, of a scale replica spring-pole drilling rig, the earliest type of drilling apparatus used by Canadian oil pioneers.

Speaking at the ceremony, F. J. Himbury, manager of public relations for Canadian Oil, said: "It is fitting that this centennial is being held at Oil Springs, as it was here that it all began." And he added that "James Miller Williams should be given his proper status as father of North America's oil industry."

Evidence on Williams' behalf is based on the findings of Colonel R. B. Harkness, former natural-gas commissioner for Ontario, and backed by Dr. J. J. Talman, chief librarian of the University of Western Ontario.

James Miller Williams was a 39-year-old businessman in Hamilton, Ontario, when he decided to dig a hole in the malodorous "gum beds" around Black Creek in southwestern Ontario. Having built and sold flourishing carriage and railway-car manufacturing business, he decided to buy out Charles N. Tripp, who about 1851 had formed a company to work the "gum beds" near Oil Springs. Tripp had found that, by boiling the muck from the "gum beds," he could make a fair grade of asphalt. In 1855, he won an honorable mention for the asphalt at the Universal Exhibition in Paris, France, but his operations were not financially successful. He sold out to Williams in 1856, becoming Williams' employee. Williams began operations in 1857 and found that, by digging and drilling in the gum beds, he could obtain oil in a liquid state. The first well was on the banks of the Thames River, near Bothwell, in Ontario's Kent County; and, after digging 27 ft, Tripp and Williams one morning found the pool full of oil and water. In trying to drive an iron pipe down the hole to reach the "pool of oil," they broke the pipe—and the well was abandoned. Williams then moved to the gum beds of Enniskillen Township in neighboring Lambton County, and here he reportedly dug 65 ft, getting more oil the deeper he dug. From this, and from wells which others dug, 5 bbl to 100 bbl per day were taken.

James Miller Williams

Williams was not satisfied with digging the first commercially successful oil well, but built the first Canadian oil refinery as well, on the banks of Black Creek. Others before him had boiled the "gum," using the residue as asphalt and throwing away everything else. Williams used a retort in which he distilled a comparatively light lamp oil, thus becoming the first to construct a Canadian refinery. He and his associates had to design and erect all their own drilling rigs, tools, and refineries with the aid of traveling handymen—designing and testing them in operation. At first, he dug until he reached rock, but some time between 1857 and 1859 he decided the best way to get at the source of his oil was to drill into the bed rock. Probably he was the first to drill a well.

In 1861, a *Toronto Globe* correspondent reported on Williams' well No. 27: "Well sunk 46 ft to rock; bore 100 ft in rock. This well averages the large quantity of 60 bbl a day. A very great deal of oil has been taken from it. It has been in operation two years."

Transporting the oil was one of the early headaches. There were no roads—only almost impassable clay trails to the railroad 16 miles away. The clay subsoil was quite impervious to water; the terrain, flat; the occasional streams, sluggish. As a result, every foot path became a mire and then a succession of pools and drains. Everyone wore knee-length boots during their waking hours, and a *Toronto Globe* correspondent reported that one man wore his boots in the hotel bed, claiming that "the bed did the boots no injury."

Williams was one of the four men who laid out the village of Oil Springs in 1860, and by 1861 there were 1,600 people there. About 1866, there was a population of 3,000, twelve general stores, nine hotels, more than 1,000 wells in production, and a "planked" main street considered the finest in Canada. Almost overnight, however, the population dropped to 300, and oil output dropped drastically. The 600 active wells today produce only about 45 bbl per well per year.

The "bust" was occasioned partly by a new town of Petrolia, built eight miles away, which won a branch of the Great Western Railway. There was also stiff competition from Pennsylvania, and in 1866 the first Fenian raid took place at Fort Erie. Anticipating a war between England and the United States, many oil men decided to return to their homes in the USA or other parts of Canada. The Petrolia field, however, continued in good production, and by 1953 the total production of the Ontario fields was 31,621,182 bbl.

Williams first operated under the name of J. M. Williams & Co., but in 1860 he applied for incorporation of the Canadian Oil Co. At the 1862 International Exhibition in London, England, the Canadian Oil Co. won a gold medal for being the first to produce crude oil, and another for being the first to refine oils in Canada. A careful man, Williams was described by one writer: "He never drilled a gusher or won or lost a spectacular fortune, but oil men said he was the one man who left the first Oil Springs boom with money in his pocket." By 1880, when American competition was keen, Williams seems to have disposed of his oil interests and founded a stamping works, one of the first in the country to make pressed tinware. He was also a director of several insurance companies, railroads, and a loan society; and served as an alderman on the Hamilton City Council and in the legislature. END

Puutalo houses in the vicinity of Helsinki

View of a residential district in Central Finland.

Prefabrication of timber houses in Finland

by Juho Savio*

The prefabricated house industry in Finland sprang up during the second world war. In 1940, the country had to find accommodation for some 400,000 refugees from the areas ceded to the Soviet Union. Certain firmly established factories of the woodwork industry then decided to establish a practically new branch of the industry—the prefabricated timber house industry. The plan was realized in a short time with the help of Finnish architects, engineers and technicians, and a central organization Puutalo Oy (Timber Houses Ltd) was also set up to deal with the planning and sales of the products of this new branch of the industry. Today, the organization functions under the name of Puutalo Sales Association for Prefabricated Houses.

The Finnish prefabricated house industry soon reached large-scale production and from the very beginning the greater part of its output was exported. Today, Finnish prefabricated houses are exported to all continents and for all types of climates from the arctic to the equator—to more than 50 countries in all. The living area of the buildings supplied amounts to some 160 million square feet. The production program has included schools, hospitals, hotels, shops, gymnasiums, cinemas, aircraft hangars, warehouses, barracks for military purposes and building sites, house components such as doors and windows and wall elements for multi-story buildings. The industry has its own saw mills, plywood and fiber board factories. Glass and rock wool as well as asbestos-cement sheets are available in Finland for insulation.

From the construction point of view Finnish prefabricated houses can be divided into two main groups: houses made of pre-cut timber and houses to be assembled from panels. In both groups there are several variations of design according to particular climate, wind force, and the possible danger of termites, and so on. These constructions can be either permanent or transportable. As a proof of the flexibility of the prefabricated house industry it is worth mentioning that the wishes of buyers with regard to the location of rooms, the architectonic appearance of houses and their particular demands associated with the living habits can be taken into consideration, whenever practicable.

Deliveries from Finland generally include the parts above the foundation, but often roof covering, window panes, kitchen fitments, built-in wardrobes, electrical and sanitary installation as well.

Detailed instructions for erection accompany each building. Since each house part has a number of its own and erection itself is easy, difficulties have never arisen during erection. Sometimes, in connection with large deliveries, an engineer has been sent from Finland at the request of the buyer to supervise the erection of the first few houses.

In cooperation with the State Institute of Technical Research Puutalo is carrying out tests with regard to the strength of timber components, glueing, thermal insulation, and so on. Special research work has also been done in cooperation with the research institutes of countries where termites abound to find effective impregnation material against the destructive action of such insects. In addition, the development of the prefabricated house industry in other countries has been followed with keen interest in Finland.

Prefabricated timber houses have proved extremely advantageous in the development of planned building settlements, and also where it proves difficult to find skilled workers for new industrial or mining areas. The best proof to show that even long sea voyages do not form insurmountable obstacles is the fact that considerable quantities of Finnish houses have been delivered to such remote places as the Falkland Islands, Australia and Kamchatka.

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* Commercial manager of Puutalo Sales Association for prefabricated houses, Helsinki.

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MARACAIBO DISASTER OF 1937—Or the Lake That Swallowed the Derrick: *Above*—Terrific oil and gas pressure undermines the piles which hold a derrick and machinery in the bed of Lake Maracaibo, Venezuela. The drilling crew makes a quick get-away in a launch as the derrick sways from the engulfing cavity below. *Right*—The derrick begins to topple. Drill pipe is forced from the hole, catches on a girt, and remains there for 1½ hours. High-pressure gas belches as from a volcano.

Left—With collapse of the derrick, the remaining drill pipe in the hole bolts free, straightens out as it shoots into the air about 800 ft. Finally, the pipe lands in the lake not 30 ft from the launch with the escaping crew. *Above*—The voracious cavern swallows machinery, derrick—everything but the drill pipe hurled into the air. Here the pipe falls back into the water. Thus ends the sad story of the "lost well of Maracaibo." (Photos by Elmo W. Adams, for National Tube Co.)

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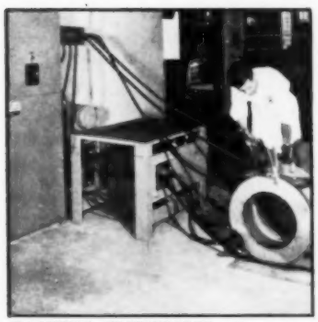
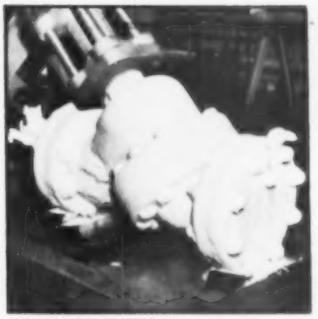


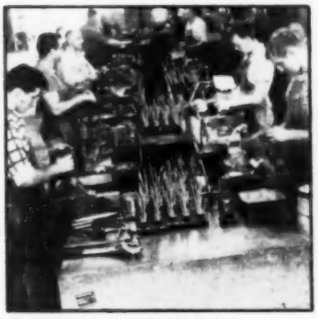
CASTING TIGHTNESS: Pressure tightness of carbon and alloy steel castings for service temperatures ranging from −423°F to +1500°F is controlled by non-destructive testing facilities at Pacific using X-Ray and cobalt 60, Magnetic particles inspection, fluid dye penetrant, zyglo and acid pickeling is used extensively for testing production castings.

CORROSION: "Tailor-made" alloys incorporated into valve castings and component parts give you added performance for severe service conditions where valves must possess any corrosive element of the process media. High quality control and availability of all types of alloys to meet any corrosive problem is made possible due to Pacific's new expanded foundry facilities.



TEMPERATURE: Because Pacific manufacturers and warehouses all types of valves to meet varied and critical temperature service conditions, you can be assured of immediate delivery and a valve that is certain to meet your specific need. Valves with operating temperature range of −453° to +1500°F are readily available in all sizes and pressure classes of 150 psi to 6000 psi.

DESIRED TRIMS: Make the most of Pacific's wide selection of trims as the logical answer to such problems as corrosive action, contamination or extreme pressure and temperature conditions. Selective body-bonnet material combinations are at your bidding for a more economical over-all operation.



INTERCHANGEABILITY: Custom-fit replaceable parts are warehoused for immediate delivery to meet both routine maintenance schedules and emergency deliveries. Interchangeable seats, disc, and trim components, either standard or special, means greater flexibility to you for a more economical, more efficient operation.

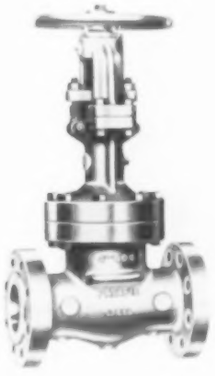
LAPPED SEATING: Solid, one-piece wedge in all small steel gate valves are ground and lapped to *a few microinch* finish, assuring leak-proof performance and uniform surface contact between wedge and seat rings.

LOX SERVICE: Pacific's complete line of steel valves for high-pressure, ultra low temperature cryogenic service affords maximum flow-minimum pressure drop for valves in critical service. Valves are available in various materials for specific pressure and temperature conditions. Government approved facilities for the specialized servicing of equipment for LOX service and similar applications.

VALVE REPAIR SERVICE: Compare this against any other valve manufacturer! Pacific valve' repair shops, strategically located near you, afford immediate attention to all your valve repair needs. Whether it be a major overhaul or minor repairs, you can be sure, with the purchase of *any* Pacific valve, the manufacturer is prepared to meet your future repair needs with valve parts originally designed for your valve.

LEAKAGE: No "spot-testing." *Each* and *every* valve tagged for shipment has been hydrostatically seat tested with air and water on both sides of the seat assuring absolute seat tightness.

STELLITE HARD FACING: All of Pacific's small steel valves (2" and smaller) can be furnished with hard face seats and discs for high pressure steam service.



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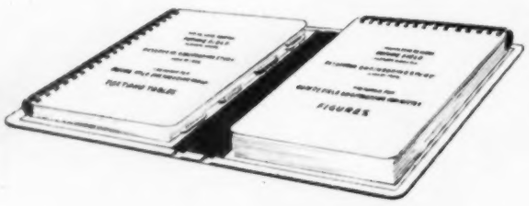

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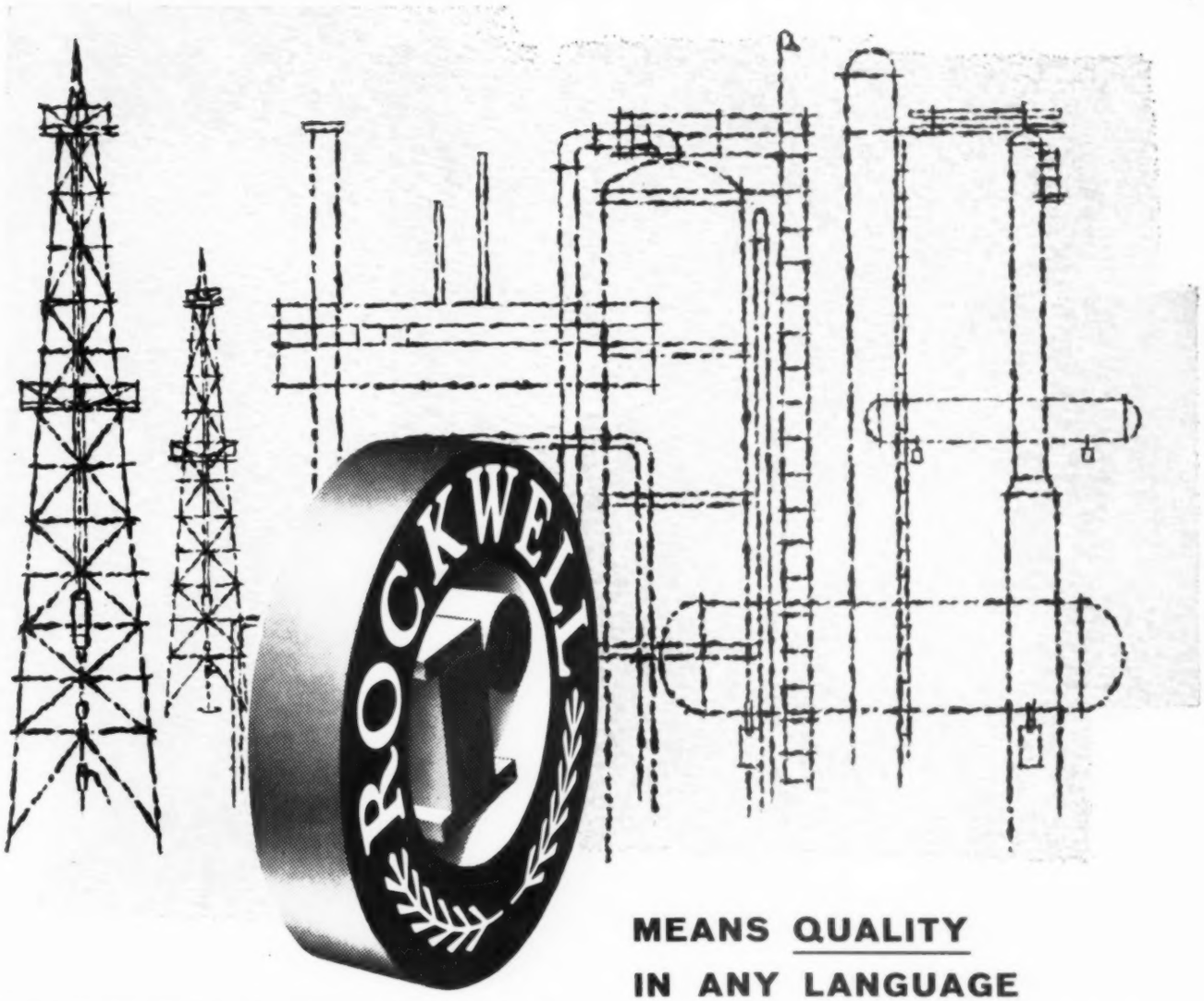

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International Division

ROCKWELL

INTERNATIONAL NEWS AND NOTES

Magellan Merges Buckley

Pan-Israel Oil Co. Inc. and Israel-Mediterranean Petroleum Inc., owned by Buckley interests, have consolidated into their wholly-owned subsidiary, Magellan Petroleum Corp. Voting trust certificates representing the 4,186,610 shares of Magellan now outstanding (out of a total authorization of 7,000,-000) will be distributed to the shareholders of the Israel companies in dissolution, in the ratio of one share of Magellan for each five shares of Pan-Israel or Israel-Mediterranean held.

Voting Trust Certificates for shares of Magellan's capital stock were admitted to "when issued" trading on the American Stock Exchange at 10 a.m., April 16.

Magellan holds a net 26,528,000-acre interest in oil concessions covering 27,328,000 acres in Australia, a 12½% interest in 1,256,000 acres in the Northwest Territories of Canada, varying interests in 252, 700 acres in Israel, a 3 to 4% royalty on 1,500,000 acres in Ecuador operated by Tennessee del Ecuador, a subsidiary of Tennessee Gas Transmission Co., and interests ranging from 25.5% to 50% in petroleum concessions and applications covering approximately one million acres in Guatemala. Active exploration work is under way on the properties in Australia and Guatemala.

Shell Discovery In Paris Basin

The Compagnie des Pétroles du Sud-Est Parisien has struck oil at Saint Martin de Bossenay, some 100 kilometers southeast of Paris, on its Aube and Yonne permit. This new find is within about 30 kilometers from Chailly-en-Biere (CEP), Chakeaurenard (Fropex), and Granville (RAP), previous discoveries in the Paris basin. The pay zone is the limestone at the top of the Dogger, as in Coulommes, the most important field in the region; at Saint Martin de Bossenay, the top of the Dogger was found at 1,371 meters, about 300 meters lower in previous finds. A test conducted gave 3.400 liters in 90 minutes of anhydrous 33.2 API light oil, free of sulfur. The well is being drilled further with diamond core drill. It reached 1.582 meters on March 31.

The well will be drilled to 2.300 meters to explore the Rethian, another producing series in the Paris basin. However, this first oil-bearing formation is estimated to be 65 meters of porous limestone; the most important pay zone yet found in the Paris basin. More wells will be drilled on the structure to determine its importance and define its limits; surveys are being made to determine new locations.

COPESEP is an affiliate of the Shell group by Shell Française, 50%; Compagnie des Produits Chimiques et Raffinerie de Bèrre, 35%; and SAFREP (government-controlled), 15%.

$200 Million For Australia

The Australian oil industry and allied industries will spend about $200 million on development projects in the next two years. This will be in addition to expenditures on marketing and oil search.

New projects in the next two years include expansion and construction of petrochemical industries at Geelong and Altona, Victoria, and at Clyde, N.S.W. At Whyalla, S.A., a 34,000-ton oil tanker, the first large modern tanker to be built in an Australian shipyard, will be constructed at a cost of $7 million. Other developments include construction of a $36 million oil refinery at Hallett's Cove, S.A., and extensions costing $27 million at Kurnell oil refinery, Sydney.

Deep Test In Australia

Under a contract between Santos Ltd., Frome Broken Hill Pty. Ltd., and Delhi Australian, a first exploratory well was spudded on March 28, 1959, in the Innamincka area of South Australia. The 14,000-ft well is the first deep exploratory test ever attempted in the Great Australian Artesian Basin. The agreement provides that the Delhi and the Frome group will spend a minimum of $2,045,-000 over a two-year period which began January 1, 1959. It is contemplated these funds will provide for the drilling of three wells, together with certain geophysical and geological work. The commonwealth government of Australia is expected to provide subsidies which would increase the total exploration expenditures for that period. If subsurface data obtained from these exploratory tests are encouraging, the group will expend a minimum of $10,700,000 by the end of 1963.

Indonesian Fertilizer Plant

Manufacture of chemical fertilizers in Indonesia for the first time moved a step closer with the recent signing of a natural-gas supply agreement between Standard-Vacuum Oil Co. and Indonesian government in Djakarta. Expected to have an important effect on agricultural production of the country and likewise to save foreign exchange for the government, the project will supply natural gas from one Stanvac's South Sumatra fields at the rate of five billion cubic feet a year to a government-owned urea fertilizer plant to be built near Palembang. The government has applied to the Export-Import Bank for funds to finance construction of the plant.

The proposed plant would have a capacity of 100,000 tons of fertilizer annually, and would be supplied with raw materials by Stanvac for 20 years by means of a 60-mile pipeline which the company would construct for that purpose. The capital investment required by Stanvac to build the pipeline, develop the gas fields, and install

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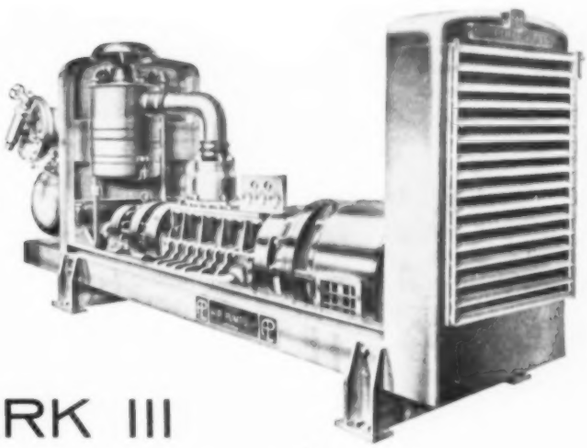

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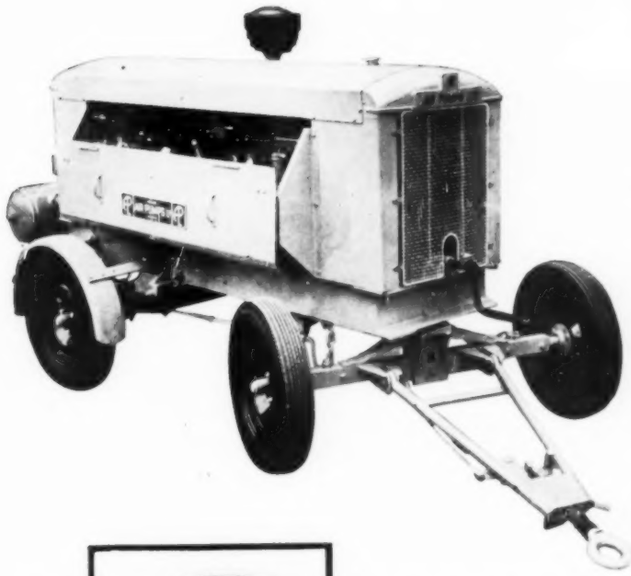

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Turkish Refinery Contract Award

Awarding of the engineering contract for a 65,000 b/d refinery at Mersin, Turkey to the Foster Wheeler Corp. of New York has been announced by Mobil International Oil Co. a division of Socony Mobil Oil Co. Inc. In making the award, Mobil International was acting as agent for Anadolu M. Tasfiyehanesi, AS (ATAS), a Turkish company which will operate the refinery. ATAS is jointly owned by British Petroleum Co. Ltd., California Texas Oil Corp., Mobil International, and the Shell Petroleum Co., Ltd.

The $50 million refinery is scheduled to go on-stream in late 1961. It is being built at the request of the Turkish government. Preliminary site investigation work at the Mediterranean port city is already under way, with construction scheduled to begin in about six months.

Initial installations will include a crude distillation, catalytic reforming, and kerosine desulfurization units—designed to process Middle East crude and produce automotive gasoline, kerosine, diesel fuel, and heavy fuel oil required by the Turkish market. In addition to the processing units, the refinery will have two berths capable of handling simultaneously two tankers of up to 50,000 tons each.

Netherlands Carbon-Black Plant

Continental Carbon Co. is to construct a carbon-black plant at Rotterdam in the Netherlands, to cost approximately $2,500,000, with initial annual capacity of 15,000 tons of high-abrasive carbon black. Continental Carbon is owned by Continental Oil Co., The Shamrock Oil and Gas Corp., and Witco Chemical Co. It will own 50% of a carbon-black installation to be built this year in France.

Construction on the Rotterdam plant will start immediately, with completion expected early in 1960, Dr. H. L. Woltersom, chairman of the Rotterdamsche Bank, has accepted the chairmanship of the new company. W. H. Thorbecke has been designated as managing director for this operation. Distribution of the products will be undertaken through the worldwide Witco Chemical Co. marketing organization.

Japanese Help For Indonesia

Indonesian sources say that officials have come to a tentative agreement with Japanese financiers for capital to permit expansion of the Indonesian army-controlled oil company Permina. The Japanese credit is to go for rebuilding of the former BPM installations in North Sumatra, now operated by Permina. The credit would enable Permina to expand annual throughput of crude oil to three million tons and to build a refinery of 10,000 b/d capacity in four years.

Indonesian sources say 100% Indonesian ownership and control is to continue, and that there is nothing to rumors that BPM Shell may institute legal action to regain control of its properties.

Laos Concession Terms

The Royal Laos government and the French firm SEEMI (Ste. d'Etudes ed d'Exploitations Minères de l'Indochine) have signed an agreement on petroleum research. A presidential decree has ratified the agreement. Under the terms, SEEMI is granted two research permits, each for five years, during which the firm must invest one billion and ninety million French francs in specified activities. Work must start by November 1959. Permits are renewable twice for five years each time. SEEMY must form a corporationtion for petroleum research and exploitation within six months of the date of signing of the agreement. Corporation must be organized according to French law.

20% of the capital of the new corporation is reserved for Lao nationals for subscription within a two-month period. If Lao nationals do not take all of it, the corporation must complete the subscription in France. 10% of the capital is to be given gratis to the Lao government. Other firms may be accepted as partners. All products obtained may be disposed of freely by the firm.

Upon discovery of a commercially productive product, defined as 50 tons a day over 30 days, the firm must seek a concession for exploitation. This runs for 40 years and may be renewed. The firm has the right to sell and export, at international market prices, the raw materials discovered, but it may be held to satisfy the local demand first. Sales to the government will be at a price equal to the firm's selling price on long- and short-term contracts during the preceding 12 months. Transportation, stocking, and treatment costs are payable by government. The firm is given eminent-domain rights for land and roads for its operations.

The government is assured of a gross revenue of 50% of the net profits as defined in the agreement. The firm is subject to the usual taxes, duties, and other fiscal changes. The firm is to pay 20 kip per year (or fraction thereof) for each square kilometer of concession; also a charge of 12.5% at fixed dates on the value of extracted products when the annual production is two million tons or more, 10% for less than two million, 8% for less than one million, and 4% for less than 500,000 tons. A penalty of 1.5% interest per month (or fraction of a month) is charged for delayed payments.

The corporation is free to dispose of its foreign-exchange earnings whether from capital or sales. The Lao government guarantees the corporation availability of foreign exchange, other than French francs or kip for its imports add other requirements.

Annex No. 1 of the agreement sets the initial investment at 30 million French francs, with investments of 90 million (five-year period) for geologic studies; 120 million (two-year period) for gravimetric studies; 250 million (two-year period) for seismic studies; and 600 million (two-year period) for drilling.

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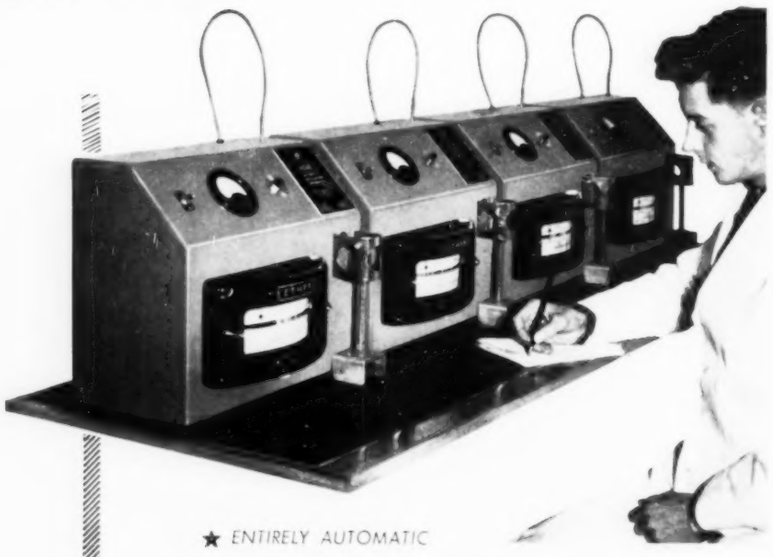

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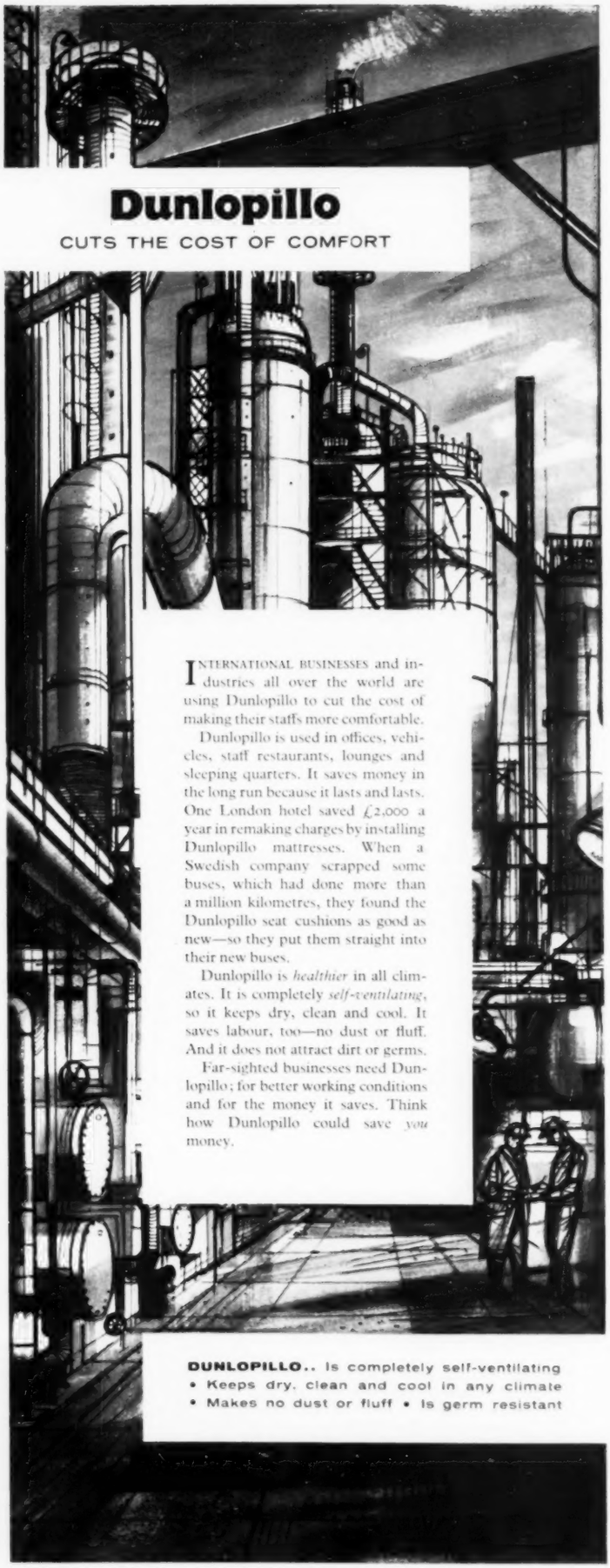

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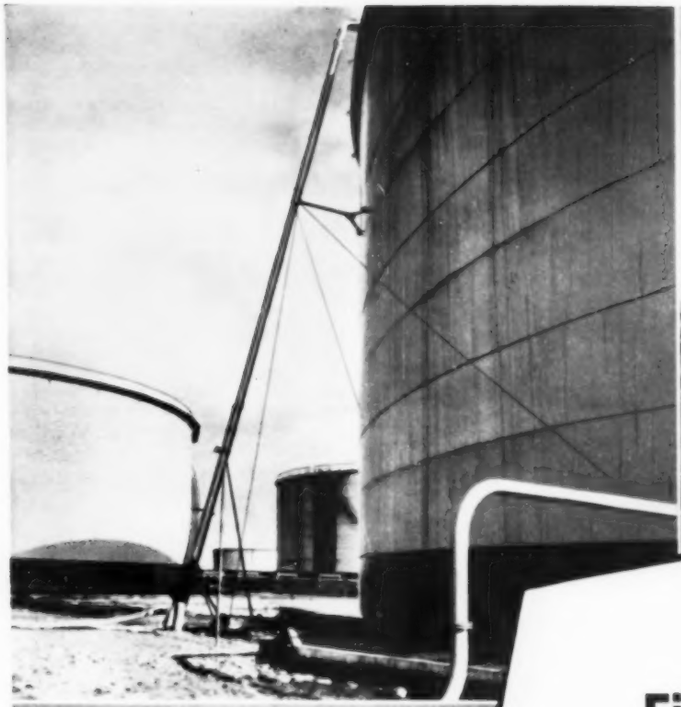

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Japanese Explore Alaska

The Teikoku (Imperial) Oil Co. Ltd. is sending managing director Washizo Terai and two drilling and geological survey experts to Alaska to check possibilities. The project, if it is worth developing, will be jointly worked on with the Polaris Prospecting Co. of the USA, which has acreage in Alaska.

More Money For Papua

Oil Search Ltd. plans to raise nearly $7 million from its shareholders to finance an increased oil search in Papua. The increased participation follows agreement by the major shareholders in the Papuan venture, British Petroleum and Vacuum Oil.

General Petroleum In Alaska

General Petroleum Corp., Los Angeles, has acquired an interest in more than 400,000 acres in the Bristol Bay area of Alaska. Approximately 350,000 acres, acquired from Great Basins Petroleum Co. et al, are within the area covered by the Becharof-Egegik development contract recently approved by the Interior Department.

1958 Iran Oil Operations

Crude-oil production in the consortium agreement area of Iran reached a record 39,800,000 tons in 1958. Corresponding payments to Iran rose to £88,250,000 (1957 figures were 34,800,000 tons and £76,400,000 respectively), according to annual report of Iranian Oil Exploration & Producing Co., and Iranian Oil Refining Co.

Exploration and drilling activities were vigorously continued: Topographic, geological, seismic, and gravity surveys were conducted throughout the agreement area, and nine drilling strings were in operation. One of the six wells brought in at Agha Jari flowed on test at a rate of 40,000 b/d.

Of the six established oil fields, Agha Jari was again by far the largest producer, with an average daily production of 503,000 bbl (out of a total of 821,000 for the six fields).

Refining at Abadan was at a rate of 310,000 b/d—slightly below the rate of 314,000 in 1957, in which year there had been an exceptionally large increase over throughput in 1956.

During 1958, a sum of £24,500,000 was actually spent on capital projects. Preliminary work was carried out for the laying of a 99-mile large-diameter pipeline, 25 miles of which will be under the sea, between Gach Saran oil field and Kharg Island. On Kharg Island, the necessary temporary installations and utilities required for construction of the new major crude-oil loading terminal were provided.

Study Bavarian Pipeline

Bavarian officials are setting up a commission to study whether Bavaria should be included in a European oil pipeline grid. Dr. Otto Schedl, Bavarian Minister of Economics and Transportation, estimated laying an oil pipeline to Bavaria and building of a refinery would cost 500 to 600 million German marks.

Ivory Coast Survey

Glen H. Albertson, of Fairchild Aerial Surveys, is due in Abidjan, Ivory Coast, to install the company's "marine sonoprobe" equipment abroad a vessel of the Cie. Abidjanaise de Reparations Navales et des Travaus Industriels. The company is to use the equipment, developed by FAS and Magnolia Petroleum Co., in offshore oil exploration, using the ship, "Sagitaire," as a mobile base.

BP In Italy

After April 27 some 1,300 selling points in northern Italy began dispensing BP products. Until that time, the direct marketing of BP products in Italy was confined to aviation and oil bunkering services in association with AGIP with whom BP has been partners in the Porto Marghera refinery at Venice since 1948. BP recently has acquired the shareholding interest in the marketing organizations in Italy of two Italian oil companies. A new marketing company, BP Italiana SpA, with headquarters in Milan, has been formed.

British Pipeline Distribution

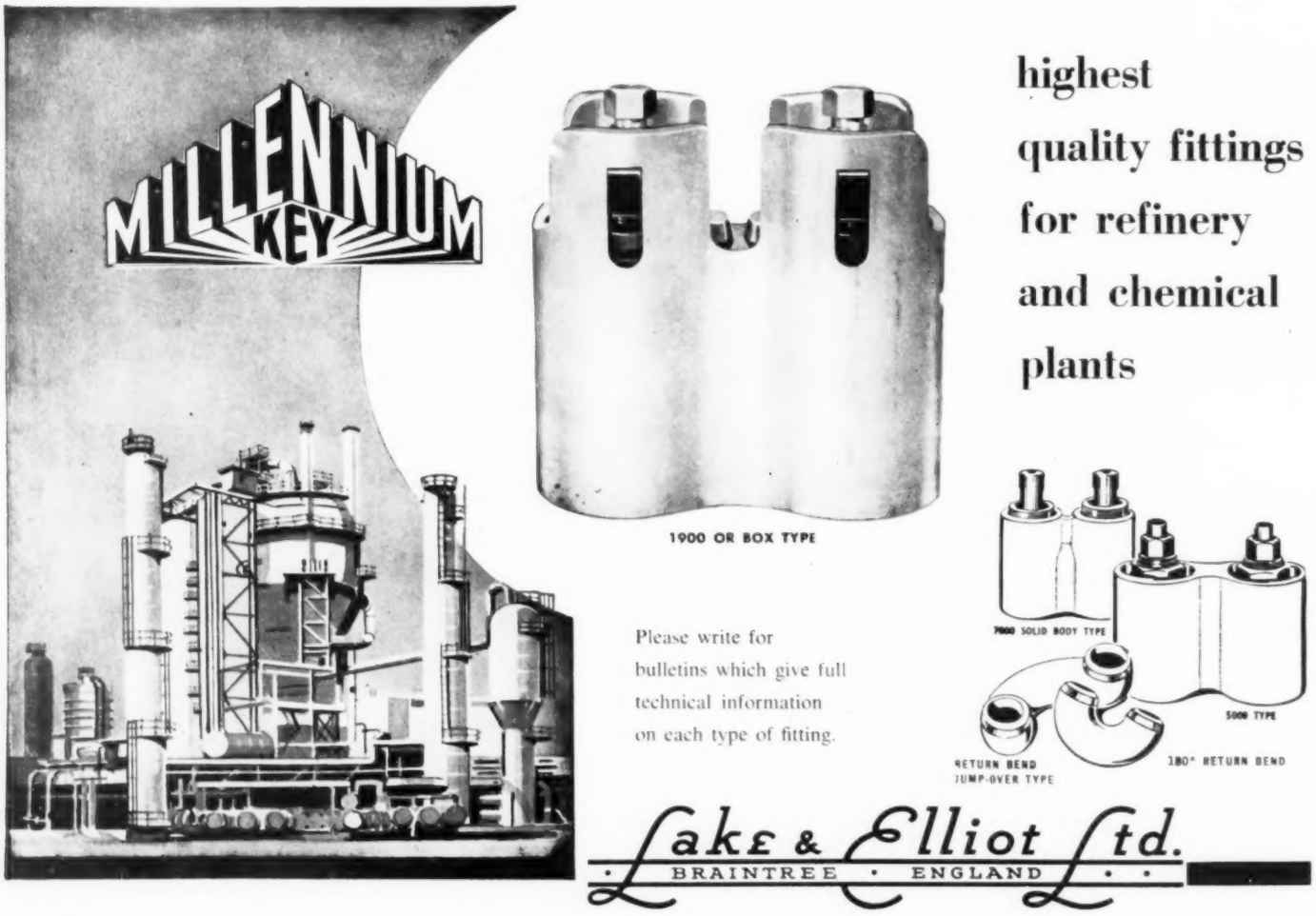
Shell Mex and BP Ltd. has started construction on a new distribution center at E. Partington, near Manchester, England, and on two 23-mile pipelines —one 6-in. and one 8-in., from Shell's Stanlow refinery. This will make the installation the first commercial multiproduct storage and distribution point in Britain to be fed solely by pipeline. Estimated cost of the two lines is £1 million, and the initial capacity of the installation will be 70,000 tons. It will replace the present 60-year-old Eccles depot, and its distribution range will cover some 1,200 square miles of Lancashire, Cheshire, Derbyshire, and Yorkshire. C. S. Martin, northwestern divisional manager, has suggested the project might be setting the pattern for future bulk distribution of oils from the coastal refineries.

Chemical Plant For Russia

A contract has been signed in London with the Russians for the supply of £2,200,000 chemical plant by Vickers-Armstrong (Engineers) Ltd. and High-polymer & Petro-Chemical Engineering Co. Ltd. The major part of the plant will be built by Vickers at Barrow, with completion towards the end of 1960. Vickers will also probably supervise the plant erection.

German Petrochemicals

The first four of a number of new petroleum-chemical plants have been commissioned at Dor-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magen, near Cologne, by Erdoelchemie' GmbH, a company in which BP Benzin und Petroleum AG has a 50% interest. Feed stocks will eventually come from the BP refinery building nearby at Dinslaken. Basic raw-material gases are being produced from a cracker and gas-separation plant, and another cracker is being erected, which together will give a total ethylene output of about 45,000 tons per year.

USA Energy Demand Forecast

Constant growth in United States energy demands in the next decade will be met easily from increasing domestic supplies of basic energy fuels, according to a panel of spokesmen participating in an "energy industries forum," sponsored by the Independent Petroleum Assn. of America.

Some of the highlights of conclusions reached by the five-man panel were: (1) USA energy consumption will increase by one-third in the next 10 years, stimulating higher living standards, greater industrial production, and a constant growth in national income. (2) Greater consumption of all forms of energy will be met by growth in energy-producing capacities adequate to meet civilian demands and the nation's defense energy needs. (3) Expressed in barrels of oil, total USA energy consumption will increase from an equivalent of 20 million barrels in 1958 to about 27 million by 1968. Or, expressed in terms of bituminous coal, total energy consumption in this period will rise from 1.5 to 2.2 billion tons. (4) USA national income, reflecting a direct relationship to the level of energy use, will rise to $500 billion in 1968 as compared with $360 billion in 1958. (5) The electric power industry, a major customer for oil, coal, and natural gas used in steam-generating plants, will build and install 140 million kilowatts of generating capacity to meet demands which will double electricity consumption in the next 10 years.

Participants in the energy forum were Morgan J. Davis, Houston, president of Humble Oil & Refining Co.; Paul Kayser, Houston, president, El Paso Natural Gas Co.; Dean A. McGee, Oklahoma City, president, Kermac Nuclear Fuels Corp.; Frank F. Kolbe, Chicago, president, National Coal Assn.; and Edwin Vennard, New York, managing director, Edison Electric Institute. Minor S. Jamison, Jr., Washington, executive vice president of the Independent Petroleum Assn. of America, moderated the forum.

Mr. Davis predicted a slower rate of growth in oil demand, and said, as a result, "the amount of effort (drilling and development) required to develop new resources to replace production and increase reserves will not increase as rapidly as in the past."

Despite a slower growth in oil demand, Mr. Davis said even a 3% annual increase in oil consumption "will call for large production and discoveries" in the future. He said the domestic oil industry, "should be able to develop three to four billion barrels annually of gross new reserves of crude oil and natural-gas liquids by the drilling of some 40,000 to 60,000 wells a year."

This drilling rate is "clearly within the demonstrated ability" of the industry, Mr. Davis added. "In order to attain these (drilling) results, however," he added, "prices must reflect at least the effect of general inflation; percentage depletion must be continued at existing rates; and oil imports must not exceed a reasonable level."

"The prospect that the domestic industry can develop during the next 20 years about three-fourths as much new oil as it has in its first century is certainly not a gloomy outlook," Mr. Davis said. "Instead, the outlook can be considered reasonably favorable provided no unwise actions are taken to discourage exploration and development."

USA Production Up 9.3% In '59

The Supply and Demand Committee of the Independent Petroleum Assn. of America has forecast 1959 domestic crude-oil production in the USA at 7,335,000 b/d, an increase of 625,000 b/d, or 9.3% over 1958 output.

Total domestic and export petroleum demand in 1959 is expected to average 9,786,000 b/d—an increase of 445,000 b/d, or 4.8% over 1958.

Domestic demand for 1959 was estimated by the committee at 9,532,000 b/d, an increase of 467,000 b/d, or 5.1% over 1958. Export demand, the committee said, will decline 22,000 b/d to an average of 254,000 b/d.

Applying the government's standards for limiting imports, the committee estimated that total imports of crude oil and petroleum products will be approximately 1,500,000 b/d in the latter half of 1959. This would be about 250,000 b/d less than the import rate in the same period last year.

In addition to crude-oil production of 7,335,000, the committee estimated that output of natural-gas liquids this year will average 839,000 b/d, making an average 1959 production of total petroleum liquids of 8,174,000 b/d.

Six new vice presidents were elected by the board of Phillips Petroleum Co., Bartlesville, Okla. Formerly managers of their respective departments, they are (left to right) Harry G. Fair, supply and transportation; R. B. Stewart, natural gas; G. W. McCullough, natural gasoline; L. E. Fitzjarrald, production; E. H. Lyon, sales; and C. C. Tate, refining.

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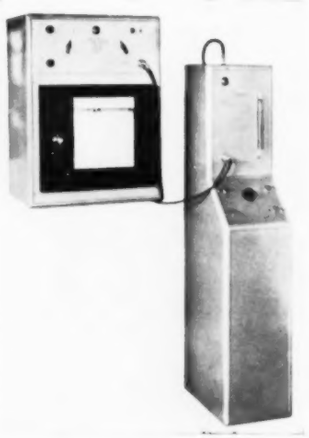

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The Pye Argon Chromatograph, using the new Argon detector originated by Dr. J. E. Lovelock, marks a tremendous step forward in the technique of gas liquid chromatography, making possible sensitivities some 100,000 times greater than previously attainable. Samples in the order of 0·1 to 0·025 microlitre can be used. Efficiencies of 1,000 theoretical plates per foot length of column are obtainable. Sensitivity range: one part component in 2×10^6 to 2×10^9 parts carrier gas (Argon) for 1 cal. on the recorder.

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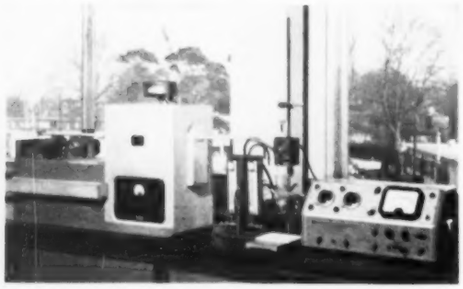

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The apparatus was developed in connection with Esso Research Limited. The illustration shows the apparatus in use at the Esso Research Centre near Abingdon.

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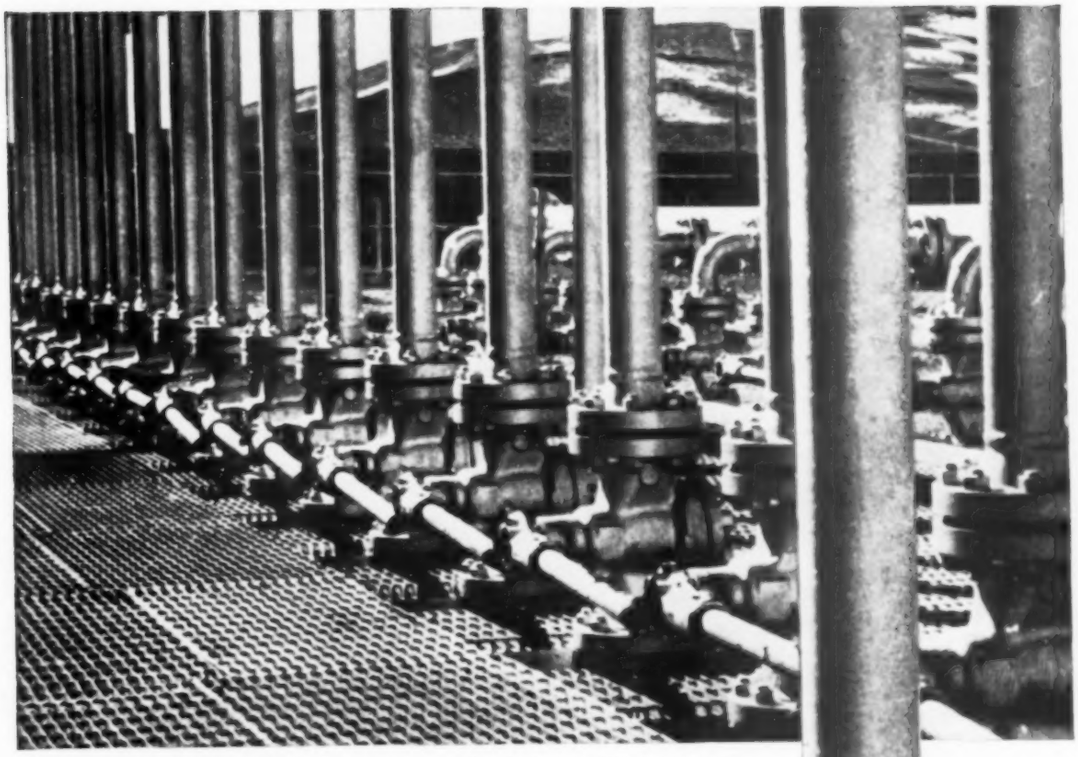

The illustration shows Audco 'Hypercal' Type valves on gathering station Inlet Manifold, Burgan, Kuwait (By Courtesy of Kuwait Oil Co., Ltd.)

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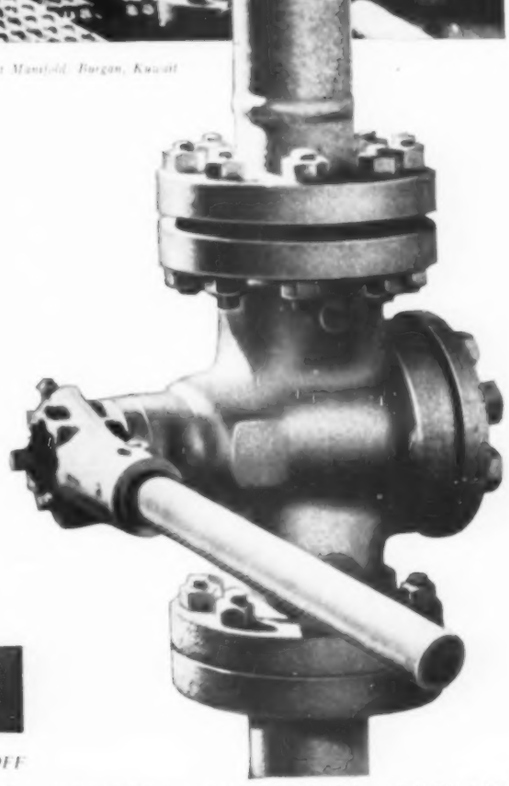

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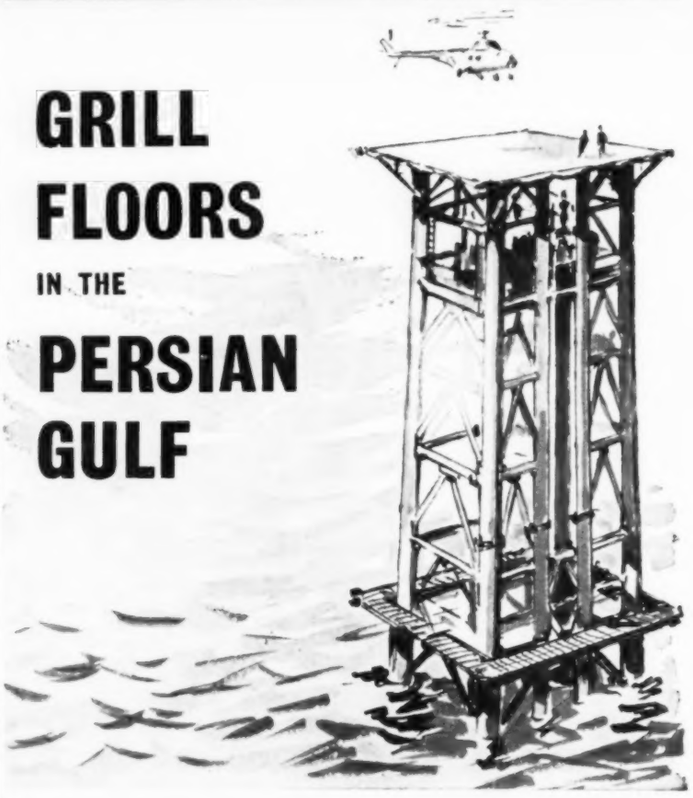

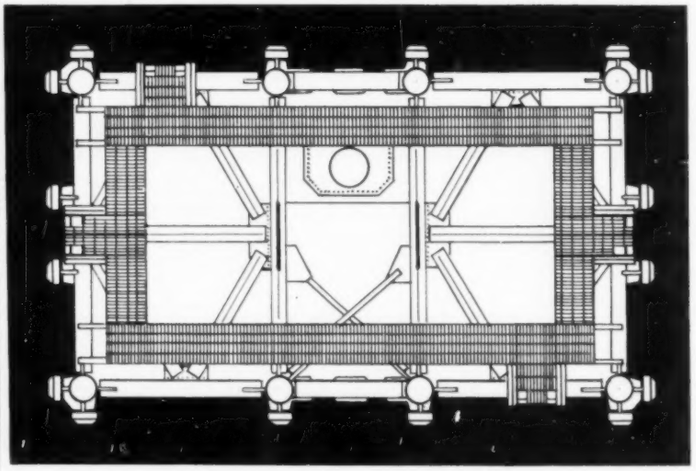

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Universal Oil Products Co., which became publicly owned in February, has joined the companies on the New York Stock Exchange. Pictured at opening ceremonies (from left) are G. Keith Funston, president of the exchange; David W. Harris, chairman of the board and chief executive officer; Maynard P. Venema, UOP president; and Mortimer Marcus, of Marcus & Co., specialists in the stock.

Plastic Piston Rings

Self-lubricating plastic piston rings for compressors which last more than 20 times as long as conventional cast-iron rings when exposed to wet hydrogen, and with a single ring taking the place of four of its metal counterparts, will be demonstrated at the Du Pont exhibit at the World Petroleum Congress in New York, May 31-June 5. Fabricated from a reinforced "Teflon" TFE-fluorocarbon resin, the plastic rings easily withstand pressures as high as 4,500 psi and perform well over a wide temperature range.

Early Congress Registration

Based on early registrations, a record attendance is expected at the six-day Fifth World Petroleum Congress which opened in New York, May 31. Well over 2,000 advance registrations had been received for the meeting as of mid-April. Fifty countries are to be represented at the congress, drawing 5,000 to 6,000 topflight oil executives, scientists, and engineers.

Of the early registrants, 1,000 are from abroad—with indications that the largest groups are to come from France (308), Great Britain (222), Germany (147), Italy (54), Canada (64), Japan (20), Spain (19), Iran (18), Turkey (10), and Mexico (15).

The opening meeting of the congress, formed in 1933 to facilitate the international exchange of scientific and technological information, opened in the Waldorf-Astoria Hotel, Sunday, May 31—with the main technical sessions to be held in the New York Coliseum, June 1 to June 5.

Gas-Well Bottom-Hole Pressure

CALCULATION OF FLOWING AND STATIC BOTTOM-HOLE PRESSURES OF NATURAL-GAS WELLS FROM SURFACE MEASUREMENTS is a volume of formulas, charts, and tables constituting a method of procedure to facilitate the determination of the performance and potential of gas wells. By Paul H. Crawford and George Fancher, it is published as *TPRC Bulletin 72* by the Texas Petroleum Research Committee at 201 Petroleum Engineering Bldg., The University of Texas, Austin 12; price $5.00.

Oil-Well Cementing Book

Equipment and highly specialized techniques used in placing cement in oil wells are reviewed and discussed in a new book published by the API Division of Production, entitled *Oil-Well Cementing Practices in the United States*. It is sponsored by the division's committees on drilling and production practice, and represents the collective effort of more than 100 experts from coast to coast. The volume is available through the API Division of Production, 300 Corrigan Tower Building, Dallas 1, Texas; price $5.00 in USA, $5.75 in foreign countries.

Sohio's Acrylonitrile Plant

Ground recently was broken at Lima, Ohio, for a multimillion dollar new Sohio petrochemical plant for the manufacture of acrylonitrile, based on a new process developed in the Sohio Research Center in Cleveland. A contract for engineering and construction of the new plant has been let to the Badger Manufacturing Co. of Cambridge, Mass., and construction is to start immediately with the completion date scheduled for early in 1960. This is the first commercial plant in the world to make acrylonitrile from propylene, ammonia and air.

Breaking ground for the new acrylonitrile plant (left to right): Edward F. Morrill, president of Sohio Chemical Co.; John Starr, vice president engineering; Badger Manufacturing Co.; Charles E. Spahr, president of The Standard Oil Co. (Ohio); and W. C. Rousseau, vice president sales, Badger Manufacturing Co.

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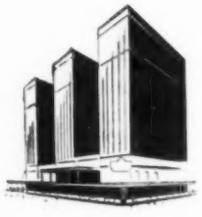

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in a new bulletin issued by the American Petroleum Institute, entitled "*Evaporation Loss in the Petroleum Industry—Causes and Control.*" Copies of the bulletin, No. 2513, may be obtained from the New York office of the American Petroleum Institute at $1.50 each. The earlier bulletin, API Bulletin 2512, "Tentative Methods of Measuring Evaporation Loss of Petroleum Tanks and Transportation Equipment," also is available at $2.00 per copy.

Research In Geochemistry

Contributions from 25 authorities make up the new book, *Researches in Geochemistry*, edited by Philip Abelson, director of the Carnegie Institution of Washington's Geophysical Laboratory. Published by John Wiley & Sons, New York, the volume consists of essays assembled at the conclusion of a seminar series conducted at the laboratory and Johns Hopkins University, 1957-58. Each chapter reviews the present status of research in the area of inquiry, describes the author's recent contributions, and contains an extensive selected bibliography. A large portion of this material has never been published before. Price is $11.50.

Gulf's New Alkylation Unit

Gulf Oil Corp. has put onstream its fifth alkylation unit, the first at its Toledo, Ohio, refinery. M. W. Kellogg designed and erected the unit. The new facilities will combine light hydrocarbons created in other refinery operations, to produce approximately 2,000 b/d of alkylate. The new unit consists of a reactor section and four distillation towers, the tallest of which is about 170 ft. Sulfuric-acid catalyst is used to promote the alkylation reaction.

Sunset International Merger

Sunset International Petroleum Corp. will acquire the assets of Warren-Bradshaw Exploration Co. of Tulsa, according to M. A. Sterling, Sunset president, and R. B. Warren, Jr., Warren-Bradshaw president.

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Old Timers Honored

Eight pioneer oil men were given special awards during the International Petroleum Exposition, May 14-23, 1959, according to announcement of William J. Sherry, chairman of the IPE "Old Timers" committee.

William L. Connelly, Tulsa, one of the founders of Sinclair Oil & Refining Corp., was named "Pioneer of Pioneers." The 86-year-old Mr. Connelly drilled his first well 64 years ago. He is still active as a special Sinclair consultant.

Seven "Grand Old Men of the Oil Industry"—each representing a division of the industry—shared the spotlight with Mr. Connelly.

Edmond C. Breene, Oil City, Pa., 81, was named Grand Old Man of Production. Born near Oil City in 1877, he first worked as a tool dresser in the eastern fields while studying law. He is now serving as chairman of Winona Oil Co. of Delaware, which he helped found in 1906.

William A. Cassidy, Bayonne, N.J., "Grand Old Man of Refining," was born in England in 1866, just seven years after the Drake well. He still lives in Bayonne where he got a job trucking at Standard Oil refinery in 1882, the year the company was formed.

Edward J. Hanlon, Tulsa, Okla., the Grand Old Man of Natural Gasoline, started to work driving a glycerin wagon in Sistersville, W. Va. One of the oil industry's most coveted awards is named for Mr. Hanlon, annually awarded by the Natural Gasoline Assn. of America.

Frank J. Hinderliter, Tulsa, 84, named Grand Old Man of Supplies and Equipment, was born in Rousville, Pa., in 1875. He was only 12 when he started to work in the oil fields, pumping wells for his father, I. N. Hinderliter. After World War I, Frank Hinderliter founded the Hinderliter Tool Co. in Tulsa.

Wiley B. Hissom, Tulsa, named Grand Old Man of Drilling, also got an early start in the eastern oil fields. As a youth, he drove his father's team of horses in the oil fields in the summer and went to school in winter. At 18 he started carrying water on a pipeline, and later became a roustabout with a drilling chew at Shinniston, W. Va.

Frank H. Lerch, New York, Grand Old Man of Natural Gas, was born in Easton, Pa., in 1888, and joined Interstate Natural Gas Co. Inc., when it was organized by Standard of New Jersey in 1926. Before his retirement in 1953, he was chairman of Consolidated Natural Gas Co.

S. Miller Williams, Robinson, Ill., one of the founders of Williams Bros. Co., was named Grand Old Man of Pipeline and Transportation. He and his brother, David R., organized the company in Fort Smith, Ark., in 1908. Their first pipeline venture was a 20-mile 8-in. line to Fort Smith.

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Impact Of Import Control

American development of oil sources abroad must be encouraged to assure supplies adequate for this country's growing energy needs, said E. L. Steiniger, president, Sinclair Oil Corp. The current mandatory oil-import control program considerably lessens incentives for such oil development abroad.

Mr. Steiniger predicted that, under the mandatory import control program, "the welcome heretofore held out by foreign governments to American prospectors and developers cannot help but be chilled. The inability of those who have invested abroad, with our government's encouragement and urging, to enjoy adequate earnings on these investments tends to invite sanctions by foreign governments whose revenues also are lessened."

Ladies Program At Congress

Members of the Desk & Derrick Club of the city of New York will be greeting women from all over the world when the Fifth World Petroleum Congress convenes in New York at the Coliseum May 30-June 5, 1959. The New York Desk & Derrick Club has the responsibility of the entertainment program for the wives of top-ranking executives, scientists, and technologists who will attend.

Nine committees are working on the overall arrangements under an executive committee composed of the club president and past presidents, with Margaret Sweeney, Sinclair, as chairman and Edith Snizek, Rand McNally, as co-chairman.

The Thornycroft Organisation manufacture and market a wide range of 4-wheel and 6-wheel drive chassis for such duties as oilfield self-loading floats for the transport of drilling rigs and well servicing hoists, or as cargo trucks, pipe carriers, explosive trucks, water carriers, also for exploration and seismic parties penetrating into the roughest kind of territory.

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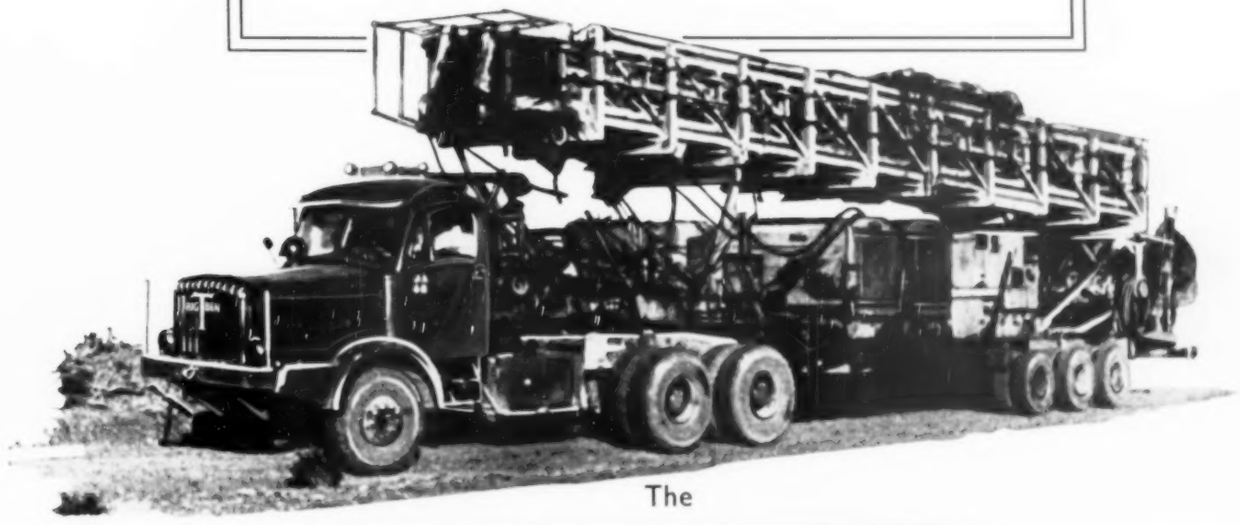

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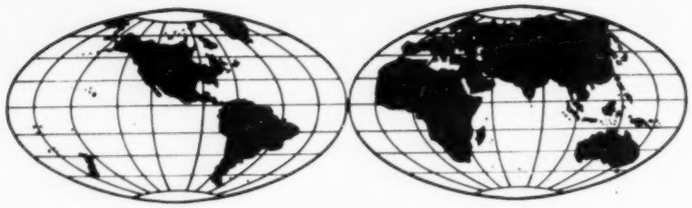

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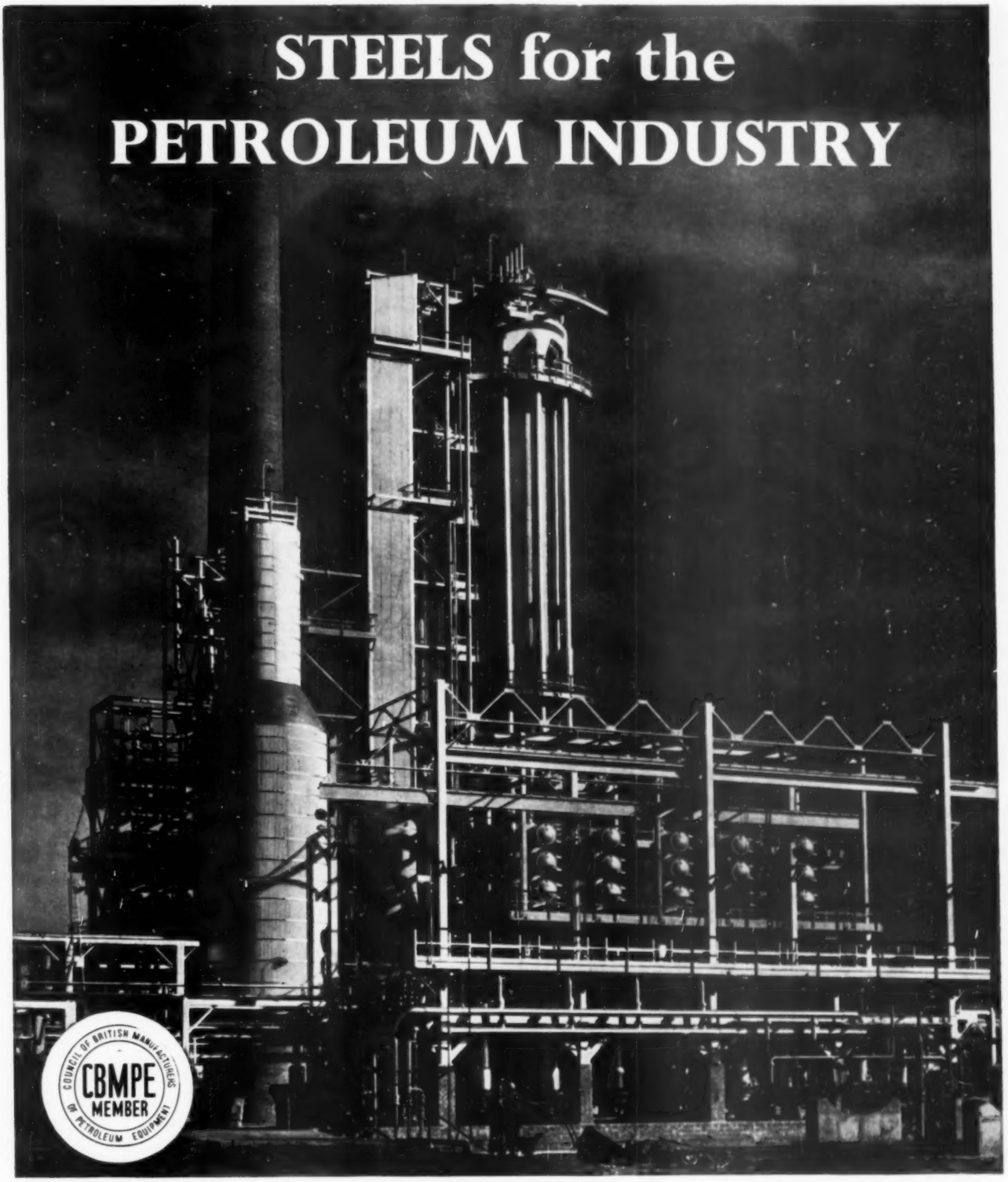

"A Symphony In Steel" —A British Petroleum Company photograph

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1958 ASTM Standards

The American Socy. for Testing Materials has completed publication of its 10-Part *1958 Book of ASTM Standards*. Each part is complete with a detailed subject index and a list of standards in numeric sequence. To keep this book up to date, supplements will be issued to each part late in 1959 and 1960. As a service, a complete index is furnished without charge with each set of the *Book of ASTM Standards*.

Higher Crude Replacement

A forecast that replacement costs for crude oil would triple between 1960 and 1970 was presented to the Eastern District meeting of the API Division of Production by Fred T. Haner, of the Regional Industries Development Corp., Pittsburgh. Mr. Haner's statistical projection indicated replacement costs for crude oil would run $1.40 per barrel by 1960, and would rise to $4.50 per barrel by 1970. At the same time, he expressed belief that drilling activity would decline because of the higher costs of finding crude-oil reserves.

Houdry Sales Realignment

Houdry Process Corp. sales department geographical realignment has been announced. Rophie E. Bland continues as manager of sales for Western Hemisphere, and Henry D. Noll continues as director, Foreign Operations, with primary responsibility for sales in the Eastern Hemisphere. David B. Arden continues as director of technical service worldwide. All three men report to J. C. Dart, vice president in charge of sales and services.

Gulf Marketing Office To Move

The Western Hemisphere Extraterritorial marketing department of Gulf Oil Corp. plans to move its operating headquarters from Pittsburgh, Pa. to Fort Lauderdale, Fla. Staff will number about 20, including clerical personnel, in a department responsible for marketing Gulf products in the Caribbean area, Central and South America. Offices will be in the Bay View Building. The move is to become effective early in September.

New Annual Refining Series

First two volumes in an annual series titled ADVANCES IN PETROLEUM CHEMISTRY AND REFINING have been published. The series is edited by Kenneth A. Kobe and John J. McKetta, Jr., Department of Chemical Engineering, University of Texas—with the assistance of an advisory board of 16 from international oil and chemical companies. The series will constitute an annual collection of progress reports written by oil and chemical authorities on particular subjects. The editors have divided the subject matter into five main sections: economics and future trends; unit operations and design; refining processes; petrochemicals; and mechanical equipment.

Published by Interscience Publishers Inc., New York, price of Vol. 1 (1958) is $13.50; and Vol. 2 (1959) $14.50.

Japanese Directory

JAPAN COMPANY DIRECTORY 1959 is published by *The Oriental Economist*, a monthly economic magazine. It lists the names, addresses, officers, and financial set up of industrial companies in Japan, including oil and chemical companies. The directory is published at Nihonbashi, Chuoku, Tokyo; price $10 overseas, including postage.

Oil Accounting

ACCOUNTING PRACTICES IN THE PETROLEUM INDUSTRY, by Robert H. Irving and Verden R. Draper, published by Ronald Press, New York; $6.00: By two CPA's long associated with oil accounting practice, this is a guide to all basic operations from leasing prospective producing properties to refining, transportation, and marketing.

Fully Automatic Refining

With no more indication than a steady glow of indicator lights and hum of electronic parts, a Thompson Ramo Wooldridge RW 300 digital computer recently took over control of processing on a nearly $4 million refining unit at Texaco's Port Arthur refinery. This is the first time in the history of automation, said Texaco president Foley, that the so-called "loop" of computer control has ever been closed on a full-scale plant operation. An increase in efficiency of 6% to 10% is expected for the unit.

Heretofore, computers have analyzed data and performed calculations *for* control, but they have never fed back their judgments into the plant and actually controlled its operations. The computer-controlled plant is a polymerization unit for making high-test gasoline blending stock. With a capacity of 15 million cubic feet of gas per day, it turns out over 1,800 b/d of blending fuel.

W. F. Lowe

Hanlon Award To Bill Lowe

The Hanlon Award, highest honor in the natural-gasoline industry and one of the ranking awards in the petroleum industry, has been conferred on William F. Lowe, executive director of the Natural Gasoline Assn. of America. Mr. Lowe is the 23rd recipient of the award, conferred each year for outstanding service to the gas-processing industry. Donor of the award is E. I. Hanlon, chairman, National Bank of Tulsa and a pioneer in the natural-gasoline business.

Oil Centennial Books

THE OIL INDUSTRY—From the Drake Well to the Conservation Era, by J. Stanley Clark; University of Oklahoma Press, Norman; $3.95: Illustrated, and with copious references and quotations from other authors, this is primarily a history of production techniques and of the oil and gas conservation movement in the USA.

PETROLEUM PREHISTORIC TO PETROCHEMICALS, by G. A. Purdy; Copp Clark Publishing Co., Vancouver, Toronto, and Montreal, Canada; and McGraw-Hill Book Co., New York; $15: By a chemist, physicist, and engineer with Imperial Oil Ltd. for 20 years, this is the story of petroleum from its geological and archaeological beginnings to the present day. Written for the general reader as well as the expert, it is completely indexed and illustrated with hundreds of photos and charts.

THE GREAT OILDORADO, by Hildegarde Dolson; Random House, New York; $3.95: By a native of the Pennsylvania oil country, this is a tale of the first "oil rush" in Pennsylvania (1859-80). Tone of the story is suggested by some chapter titles: Mr. Dickens' gorilla looms over a derrick; diamonds dunked in oil; John Wilkes Booth wants a gusher; from Petroleum Center to Paris.

TITUSVILLE 1859—A Novel About the Birth of the Oil Industry, by Leon McNierney; Vantage Press, New York; $2.95: Another gold-rush tale of the birth of oil—with its early investors, geologists, inventors, farmers, well hands—all who were involved in the historic event.

COVERED WAGON GEOLOGIST, the memoirs of the late Charles N. Gould; University of Oklahoma Press, Norman; $4.00. A belated appearance of the reminiscences and experiences of the legendary Charlie Gould, who for 60 years rock-hunted the Southwest. ". . . the story of the Ohio country boy who was born in a log cabin, lived in a dug-out in Kansas, and who on a hot August night 57 years ago received his inspiration from a geologist who held up before a roomful of country school teachers two slabs of red sandstone."

THE ROAD FROM HANOVER: Booklet on a convocation commemorating the 100th anniversary of the first scientific examination of crude oil conducted at Dartmouth College, 1853. Four addresses. In one, Dr. Paul H. Giddens, oil historian, points out some little-known aspects of the early beginnings of the oil industry and Dartmouth's place in them.

BP Reports 1958 Gains

In its preliminary annual report for 1958, British Petroleum Co. Ltd. reports sales of crude and refined products of the BP group last year totaled 62 million tons, compared with 53 million in 1957. The board recommended a final dividend for year 1958 of 1s 3d (17.5 cents) per £1 unit of stock, free of income tax, making a total for 1958 of 1s 9d (24.5 cents) per ordinary share on present increased capital. Company declared a 100% stock dividend, September 11, 1958. Based on the present increased capital, the corresponding total dividend for 1957 was equivalent to 1s 6d (21 cents) per ordinary share.

Consolidated net profit of the BP group in 1958 amounted to £61,922,563 ($173,383,176), a gain of 19% over previous year.

Sun For Tariffs

Sun Oil Co. has renewed its proposal to bring about a reduction in foreign oil imports through the imposition of appropriate tariffs as a substitute for the current mandatory quota restrictions. Sun's president, Robert G. Dunlop, urged this course of action as necessary to avoid current federal "policing of oil prices," which he said "may lead to further controls over the petroleum industry."

Decline To Attend Congress

The Soviet Union has cancelled its arrangements to send oil scientists to New York to attend the Fifth World Petroleum Congress, opening May 31. Notice of this change came in a cable to C. E. Davis, congress general secretary, from Professor A. V. Topchiev, vice president of USRR Academy of Science.

Professor Topchiev said that "conditions of a discriminaatory nature" have been imposed on Soviet scientists who were to attend. This probably refers to State Department's policy not to permit scientists from the Soviet Union to visit certain areas in the USA unless reciprocal rights to USA oil men were granted by the Soviet Union.

BP Thermal Reformer

BP Trading Ltd. has now placed on stream at its Kent Refinery a 12,500 b/sd thermal reformer designed by Kellog International Corp., London. The unit is designed for single pass thermal reforming of either light or heavy naphtha fractions from Middle East crudes to product a debutanized reformate of maximum research octane rating. The unit is also capable of handling Platformates of similar boiling ranges.

German Book on Oil Technology

"*Kleine Technologie des Erdoels*," by Heinrich Ruf, Dr. Sc. techn. (Publisher: Birkhaeuser Verlag, Elisabethstrasse 19, Basel 10, Switzerland) is a book (258 pp.; price: sFr 26.-) which gives—in concise form and supported by 132 well-selected photos and 40 tables—an excellent review of the methods used in the manufacture of mineral-oil products. There are some newer methods developed in America and Russia which have not been mentioned in this small volume—and nobody should expect to find them there.

Dr. Ruf, who for many years worked for Royal Dutch-Shell and other big companies in Asian and South American oil fields, in control and research laboratories, and in refineries, is at present a Swiss government officer in charge of oil products and also a lecturer on the Technical College. This book describes in systematic order (in 4 parts) origin, exploration, production, transportation, storage, and chemistry of oil and its compounds; distillation and adsorption methods; cracking, synthetic processes, refining; processing schemes for various types of oil, other carbohydrate sources, and petroleum chemicals.

Australian Investment

Standard Vacuum Oil Co. investments in Australia will exceed $255 million by 1960, according to H. F. Prioleau. This would make Australia Stanvac's largest investment center of the 50 countries in which it operates. Work on a refinery at Adelaide would bring the investment above $255 million.

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OIL COMPANY STAFF CHANGES

GEORGE A. BIRRELL has been appointed general counsel of Mobil International Oil Co. He succeeds W. L. King, who is retiring after 20 years' service with Socony Mobil.

GLENN M. FEDDERSON has been named chief geologist for Murphy Corp., El Dorado, Ark. He has been staff geologist at El Dorado since 1954.

JOHN R. SABINA has been named manager of the tetraethyl lead and planning section of the Du Pont Co.'s Petroleum Chemicals Division—succeeding T. Baldwin Pickett, retired after a 33-year career in the petroleum industry. Mr. Sabina, who joined the company in 1937 to head a new group formed in its organic chemicals department to develop chemicals for the petroleum industry, designed and became the first director of the company's petroleum laboratory at Deepwater Point, N. J.

JAMES M. BIRD, vice president of Seismograph Service Corp., has been elected to the SSC board. He was named vice president in charge of well-logging activities in January, following the purchase of Birdwell Inc. by SSC.

EVERETT W. HUBBARD, Jr. has been named assistant to the vice president in charge of refining of Kerr-McGee Oil Industries Inc., Oklahoma City. He formerly was senior mechanical engineer of the company's Cushing, Okla., refinery.

FRED A. DAVIES, chairman Arabian American Oil Co., has retired, bringing to a close an active association with Middle East petroleum which spans nearly three decades. Board chairman since 1952, Mr. Davies also was Aramco's chief executive officer until October 1958, when president Norman Hardy succeeded him in that position. Previously Mr. Davies had been Aramco vice president in charge of exploration and production and executive vice president.

J. HOWELL TURNER, new general manager of employee and public relations, has been elected to the board of Standard Oil Co. (Indiana), Chicago—replacing, as a director, Dr. William J. McGill, retired after 34 years' service.

ROBERT H. MARTIN has been appointed manager, in New York, of Texaco's Trinidad Operations. A graduate of Miami University, Oxford, Ohio, he joined Texaco's domestic producing department in 1942 as a geologist. In August 1958, he was appointed secretary of Texaco's executive producing committee in New York.

N. W. MANN has been named vice president in charge of USA and Canadian operations, and **G. J. KOHLER, Jr.**, vice president for Latin America, of Geophysical Service Inc., Dallas, Texas. Mr. Mann formerly was manager of western USA operations, and Mr. Kohler has been manager of GSI operations in Latin America since 1957. **RAY H. WRIGHT** will take over the position vacated by Mr. Mann in Dallas; and **DAN F. BRENNAN** will succeed Mr. Wright in Canada.

Dr. JOSEPH E. POGUE, a director and petroleum consultant of Gulf Oil Corp. since 1949, has resigned both positions. He is succeeded as a director by **FRANK R. DENTON** vice chairman, a director, and chief executive officer of the Mellon National Bank & Trust Co.

VICTOR H. PETERSON, of New Canaan, Conn., has been appointed assistant manager of the public-relations department of Standard-Vacuum Oil Co., White Plains, N. Y.

GEORGE A. GUMBS, Jr., has been elected vice president of Esso Tankers Inc., marine affiliate of Standard Oil Co. (New Jersey). Manager of the Esso Tankers traffic department, Mr. Gumbs has been active in ocean tanker activities with Jersey Standard and its affiliates for over 40 years. He joined SONJ in 1917.

ROBERT T. PARRISH has been appointed head of employee relations group of Creole Petroleum Corp's New York office. He replaces George T. Culp, who is returning to Venezuela as industrial relations coordinator in Creole's office in Caracas.

Mr. Parrish joined Creole in 1948 as a training supervisor in the company's industrial relations department in Caracas. In 1951 he transferred to western Venezuela, and in 1957 he was named district industrial relations supervisor at La Salina.

JOHN B. KRIZER has been named assistant manager of Cities Service Oil Co.'s supply & distribution division, Bartlesville, Okla. A long-time Cities Service employee, he joined the company in 1934. He was named sales manager of the refining division in 1955, and transferred to supply and distribution three years ago.

BERT W. NICHOLS has been elected treasurer, and CHARLES S. ALLEN assistant treasurer, of The Standard Oil Co. (Ohio), Cleveland. Mr. Nichols succeeds E. W. Allgower, retired after 42 years of service. Mr. Nichols joined the company in 1931, and was elected assistant treasurer in 1955. Mr. Allen joined Ohio Standard in 1918.

PETER A. BLASKO, former general manager of refining, Aurora Gasoline Co., Detroit, has been named vice president-manufacturing, The Vickers Petroleum Co. Inc., Wichita, Kans. He succeeds A. M. "Bob" Schrepfer, retired.

FRED E. SMITH, vice president and manager of domestic production of The Ohio Oil Co., has retired after 45 years with the company. **GLENN F. BISH**, assistant manager, has been elected vice president and manager, and will succeed Mr. Smith.

HAMILTON P. CALDWELL, manager of Mobil Oil Co.'s Augusta, Kans., refinery since August 1957, has been named to the newly created position of manager of manufacturing in Mobil Oil de Venezuela, with headquarters in Caracas. Mr. Caldwell will be succeeded by Joe E. Penick, who returns to Augusta from East Providence, R. I., where he has been managing the company's refinery. Mr. Penick served as Mobil's chief process engineer at Augusta from 1952 to 1956. **DAVID CHRISTISON**, assistant to the manager of Mobil's Buffalo refinery since July 1958, has been named to succeed Mr. Penick in East Providence.

CHARLES E. WEBBER, technical advisor to the vice president, Sun Oil Co., Philadelphia, has been elected president of the Natural Gasoline Assn. of America for 1959-60. Before joining Sun Oil Co., he had been with Humble Oil & Refining Co. Winner of the 1957 Hanlon Award, Mr. Webber has been chairman of the NGAA Technical Committee since 1953.

R. W. HINES, former production manager, has been elected vice president for production for Texas Pacific Coal & Oil Co., Fort Worth, Texas. **J. W. YARBRO** has been named vice president, financial; **J. I. NORMAN**, secretary and assistant treasurer; and **HARRY O. ANDERSON**, treasurer and assistant secretary. **D. A. BONNEY** succeeds Mr. Hines as manager of production. **MILES HART**, of Texas Pacific's legal staff, becomes general attorney. **RUDOLPH SEIBEL**, with Texas Pacific for 40 years, has retired as vice president, treasurer, and secretary. **J. R. TEAGUE**, a 30-year veteran, has stepped down as vice president for production.

ARTHUR S. RANDAK

Arthur S. Randak, assistant eastern division manager of Sinclair Refining Co., died, May 5, in Boston at age 46. Mr. Randak was also a colonel in the US Air Force Reserve and Commander of the reserve's New York Research and Development Squadron. He was also a director of Sinclair Research Laboratories Inc., and chairman of Sinclair Refining Co.'s motor-fuels steering committee.

EDWARD P. FISCHER has been elected treasurer of Socony Mobil Oil Co. Inc., New York—succeeding Victor B. Geibel, retired. Mr. Fischer joined the company in 1925, and has been an assistant treasurer since 1946.

JAMES E. FINLEY, Fort Worth, has been promoted to manager of exploration for Continental Oil Co.'s southwestern region. Formerly assistant southwestern region exploration manager, he will continue to make his headquarters at Fort Worth, and will succeed D. D. Christner, who retired, March 31.

A. F. REED, vice president of Lion Oil Division of Monsanto Chemical Co., El Dorado, Ark., has retired after 30 years' service.

CANADIAN NOTES

R. C. BROWN, Calgary, Alberta, has resigned as president and director of Hudson's Bay Oil and Gas Co. Ltd. **G. T. PEARSON**, Fort Worth, Texas, southwestern regional general manager for Continental Oil Co. of Delaware, will succeed Mr. Brown as president and director of the company. Mr. Brown will become a vice president and a director of Continental. His headquarters will be in London, England, and he will be the foreign representative of Continental Oil Co.

GEORGE H. GALLOWAY, vice president and manager of the Canadian division of Pan American Petroleum Corp., returned to the company's general office at Tulsa, Okla., as vice president-exploration, effective May 1. **FRANK C. OSMENT**, who has been elected a vice president and director of the firm, will become division manager at Calgary to succeed Mr. Galloway.

GEORGE J. BLUNDUN, chief geophysicist of Home Oil Co. Ltd., and an authority on the seismography of the Alberta foothills, has been nominated a candidate for vice president of the Society of Exploration Geophysicists. He is first Canadian ever nominated to the executive of the society.

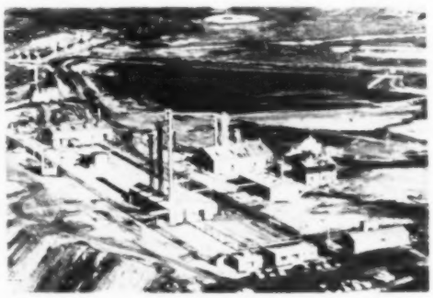
THOMAS H. JONES has resigned as chairman of Scurry-Rainbow Oil Ltd., and John F. Langston, a director, has been named his successor. Mr. Jones will continue as a consultant and a director of the company. Maclean E. Jones Q.C., a partner in a Calgary and Edmonton law firm, becomes secretary of the company.

J. P. YATES has been appointed vice president of Alaska-Yukon Pipelines Ltd., and Alaska-Yukon Refining Co., Vancouver. Mr. Yates has served for the past five years as a senior vice president of Fluor Corp. of Canada Ltd.

GLEN W. PECKHAM has been appointed assistant general manager of Prairie Pipe Manufacturing Co. Ltd., Regina. He will continue to serve as sales manager, a post which he has held for the past two years.

R. E. URTON has been appointed Calgary division production manager, Shell Oil Co. of Canada Ltd. He replaces W. L. Grossman, who will be on a training assignment in the United States.

Mr. Urton joined Shell Caribbean Petroleum Co. in Venezuela as an exploitation engineer in 1946. He came to Calgary area in 1953 and, prior to his new appointment, was division exploitation engineer at Calgary.



British American Oil's gas-conservation plant at Nevis, Alberta, is undergoing a $1½ million expansion.

LATIN AMERICAN OIL NEWS

Brazilian Market Affiliate Sold

Gulf Oil Corp. has sold its Brazilian marketing subsidiary, Companhia Brasileira de Petroleo "Gulf," to Ipiranga SA Cia. Brasileira de Petroleos, a large independent Brizilian refining and marketing company. Gulf has also entered into an agreement for a long-term supply of crude to Ipiranga.

H. L. Burns has been promoted to manager, and **Jolly D. Backer** advanced to assistant manager, of the Mexico and Central America office of Phillips Petroleum Co.—with headquarters at Av. Juarez 42 (D.) 303, Mexico 1, D.F. **Harry C. Jordan** has been promoted to manager of the Argentina office, with headquarters in Buenos Aires—address to be announced later. These new appointments are in connection with recently organized foreign sales and development department of Phillips.

Import Licenses Canceled

The Petroleum Council has agreed to the petition in which Petrobras, as one of the organizations charged with imports of petroleum derivatives for national consumption, asks to be made exclusively and entirely responsible for such imports; consequently, the authorizations hitherto granted to other enterprises have been cancelled.

Brazil's Oil In 1958

Wells drilling in January 1959: 32; wells spudded in 1958: 148; wells completed in 1958, 139—of which 81 were producers, 42 dry, 15 "strats," and one injection. As of March 1959, 53 rigs were operating, 5 stacked.

Footage drilled in 1958: wildcats and strats, 434,235 ft, development wells, 245,567 ft. Comparative figures for 1957: 99,709 and 205,705.

In December 1958, 41 teams were operating, including 5 organized during the year. Expressed in party-months, the 1958 program was carried out by 153 surface geological, 181 seismograph, and 136 gravimetric, as against 135,165, and 100, respectively in 1957. Value of crude production: U.S. $61.1 million, of which U.S. $34.7 million was processed in Brazil and U.S. $26.4 million was exported.

Imports of crude and refined products: net values in millions of U.S. dollars: 1956: 280; 1957: 256; 1958: 252.

	December 1958	*Target for 1961*
Crude production, b/d	62,252	110,000
Refining capacity, b/d	160,500	333,000
Tonnage of tanker fleet	231,000	561,000
Saving on exchange in millions of US $	121.6	312.0

Perobras will invest over 3,000 million cruzeiros in carrying out the 195 program; of this, 800 million will be applied in Bahia.

The Minas Gerais state government has appointed a commission to study the construction of a refinery at Belo Horizonte, the capital, and a pipeline between that city and Rio de Janeiro.

An agreement has been signed by Petrobras with Standard Oil under which the latter will acquire 30 million barrels of Bahia crude, of high paraffin content, valued at US $85 million, during three years, or until the national refineries are equipped to process it.

BRAZIL—RELATION OF NATIONAL PRODUCTION TO CONSUMPTION

January to November 1958 (Barrels)

	Production	Consumption	Relation
Liquefied gas	1,913,087	2,391,496	80.0
Aviation gasoline	—	2,648,679	—
Motor gasoline A & B	16,394,301	22,637,395	72.4
Kerosine	1,765,644	4,150,947	42.5
Diesel oil	5,534,159	13,596,993	40.7
Fuel oil	16,797,843	25,200,455	66.7
Lubricants	—	1,283,172	—
Asphalts	809,788	809,788	100.0
Solvents	666,446	666,446	100.0
	43,881,268	73,385,371	60.0

The only microwave system in Peru is operated by the International Petroleum Co. Covering 22 miles, the two-station one-hop system provides communications between IPCO's oil-production and refining activities in Talara and its production field offices in El Alto. The system was installed by V. M. LaPierre & Cia S.A., Motorola distributor in Peru. The Talara station is located atop a bluff near that city. The microwave antenna is mounted on a marine light beacon tower.

BRAZIL PRODUCT CONSUMPTION

(Barrels Per Day)

	1955	1956	1957	1958[1]
Liquefied gas	2,671	4,426	5,719	7,160
Aviation gasoline	5,666	6,234	6,988	7,930
Motor gasoline A & B	59,902	62,328	61,560	67,777
Kerosine	12,464	18,261	11,318	12,428
Diesel oil	28,362	38,066	32,018	40,710
Fuel oil	67,228	64,745	67,558	75,450
Lubricants	3,729	5,706	2,060	3,482

[1] Average January to November
Source: National Petroleum Council

Brazilian Companies In Bolivia

President Kubitschek has approved the Petroleum Council's conclusions that "Union Brasil Bolivia SA," "Petroleo da Bolivia SA Petrobrol," Companhia Petrolifera Brasileira Petrolanse," "Petroleo Andino SA," and "Petroleo Brasil SA" be authorized to operate as petroleum enterprises; that, as they possess the necessary technical and financial capacity, they be accredited vis-à-vis the Bolivian government to apply for and obtain concessions to exploit petroleum in area "B," defined in the formal agreement between Brazil and Bolivia; that, to obtain foreign currency to exploit the oil, the system of swaps should be adopted, unless the concessionaire prefers to resort to the free-exchange market. The following methods are also adequate: conventional loans, with bank guarantee; exchange auctions sponsored by the Comptroller of Currency and Credit. The enterprises themselves must obtain necessary exchange resources. The Brazilian authorities will extend equal treatment to each enterprise and collaborate as far as possible to guarantee the success of the undertaking.

Venezuelan Producer

A well flowing 6,640 b/d has been completed in Lake Maracaibo by Signal Oil & Gas of Venezuela. The new development well, Centro No. 16, produced 26-gravity clean oil from the Eocene on a two-hour test. Signal's three rigs on the 28,000-acre concession currently are drilling two development wells and one exploratory.

Tekoil In Argentina

Petroleum Technologists Argentina, newly formed subsidiary of Tekoil Corp., Dallas, commenced operations in Buenos Aires in May. Dr. Norris Johnston, president of Petroleum Technologists Inc., of Dallas, American counterpart of the new Argentine laboratory company, has been in Buenos Aires making final arrangements, assisted by James D. Richards, manager of the company's Bogota, Colombia, laboratories. Equipment and materials are being shipped to the new location.

Mexico Invites Participation

Inviting private enterprise to cooperate with Pemex for Mexico's oil and chemical development, Engr. Pascual Gutierrez Roldan, newly appointed director general of Petroleos Mexicanos (Pemex), said oil will be the backbone of the Mexican economy for many years to come. Addressing a group of 500 leading oil executives at a luncheon tendered Señor Roldan by John B. O'Connor, president of Dresser Industries Inc., Señor Roldan said the fact that the Pemex budget amounts to 70% to 75% of his country's entire national budget has not heretofore been generally known.

"For the past 15 years Pemex has undertaken one of the greatest industrial integrations ever achieved," Señor Roldan continued. "From scratch, production has been built up to 300,000 b/d. Mexico's consumption . . . increased at the rate of 8% to 12% a year. American suppliers have been the greatest help because of their willingness to place confidence in Pemex and our long-range program. . . .

"The most important project that we have at present is the building of the gas lines from the fields of Tabasco to Mexico City"—a 24-in. line which will be able to carry under full operation more than 500 million cubic feet of gas per day, thus releasing more than 50,000 b/d for other purposes.

To increase overall Pemex revenue and to integrate for the country's growing demands Señor Roldon said "We are going to expand into the field of petrochemicals"—with three different approaches: (1) capital investments by Pemex, with Pemex maintaining absolute control; (2) in another area, Pemex to invite private enterprise to cooperate for mutual benefit of investors; (3) in a wide-open area, Pemex will act as promoter or expediter to give 100% opportunity to private enterprise. Plans are to make the oil, steel, and chemical industries the three principal supporters of Mexico's national economy, "in order to free our future from the hazards of dependence on a single source of income."

"The greatest chance for risk capital and the higest possibility of good guarantees exists in countries like Mexico," said Senor Roldan. "The policy and economics demand that, in countries like ours, State intervention in private enterprise is good as long as the State remains in merely the role of an enterpreneur. That . . . is just what Mexico's government is doing and plans to do."

New Cuban Exploration

A seismic crew of Century Geophysical Corp. of Cuba, wholly owned subsidiary of Century Geophysical Corp. of Tulsa, Okla., will inaugurate the first oil exploration undertaken in Cuba under the new political regime.

New Brazilian Wildcat

A new Brazilian producing area in the old Bahia Reconcavo vicinity was opened up with a wildcat well at Taquipe, near the town of Sao Sebastiao. The well produced about 300 b/d on test.

Brazil-USSR Barter

Brazil's Peterobras and USSR have agreed to experimental shipments of 60,000 tons of Soviet oil against 20,000 bags of Brazilian cocoa as first step in a wider barter which would see Russia providing 200,000 tons of oil for 80,000 bags of cocoa.

J. B. O'Connor, president (left) and H. N. Mallon, chairman, Dresser Industries Inc., present Engr. Pascual Gutierrez Roldan (center), newly appointed director of Petroleos Mexicanos (Pemex) with golden symbol (safety hat) of petroleum workers.

SECTION I

ADVERTISERS' INDEX

(Advertising Agencies in Italics)

Air Pumps Ltd. 235
James Sutherland Ltd.

American Petroleum Institute 117
Sullivan, Stauffer, Colwell & Bayles, Inc.

Ashmore, Benson, Pease & Company 1

Audley Engineering Company, Ltd. 243
Edward Hilton Advertising Ltd.

Austin Hopkins & Company Ltd. 46-48
Robert Sharp & Partners Ltd.

Automatic Telephone & Electric Company Ltd. 224
Dorland Advertising Ltd.

Barnes & Bell Ltd. 241

Baroid Division, National Lead Company 102
Marsteller, Rickard, Gebhardt & Reed, Inc.

Beckman Instrument, Inc. 49
Charles Bowes Advertising, Inc.

Bible Geophysical Company, Inc. 198
Ullrich & Brown Advertising

Birkett, Billington & Newton Ltd. 234
S. C. Peacock Ltd.

Black, Sivalls & Bryson, Ltd. 129
Potts, Woodbury, Inc.

Badger Manufacturing Company 42-43
F. P. Walther Jr. & Associates, Inc.

British Ermeto 173

The British Petroleum Company Ltd. 14-15, 221
S. H. Benson Ltd.

The British Petroleum Company, Ltd. 140-141
Doremus & Company

Burton Delingpole & Company Ltd. 189
S. H. Wright & Company Ltd.

Byron Jackson Tools, Inc. 130-131
(A subsidiary of Borg-Warner Corporation)
John Ramsey Company

California Texas Oil Company, Ltd. 5
Gaynor & Ducas, Inc.

Camdrill International Inc. 33

Cameron Iron Works, Inc. Cover II
Boone & Cummings

Canadian Pittsburgh Piping 149
Walsh Advertising Company, Ltd.

The Cape Asbestos Company, Ltd. 52-53
Taylor Advertising Ltd.

Catalytic Construction Company 90
Doremus-Eshleman Company

Causeway Reinforcement Company Ltd. 188
Max Arnold Ltd.

Chemical Construction Corporation 185
Godwin Advertising Agency

Chemical & Insulating Company, Ltd. 199
Saward Baker & Company, Ltd.

Chicago Bridge & Iron Company 39
Russell T. Gray, Inc.

Chiksan Company 51
The McCarty Company

Cities Service Oil Company 105
Ellington & Company, Inc.

Clark Brothers, One of the Dresser Industries 31
The McCarty Company

Societe J. Cocard, Lille 194
Perfex Publicite

Conorada Petroleum Corporation 214

The Cooper-Bessemer Corporation 112-113
Griswold-Eshleman Company

Core Laboratories, Inc. 232
Duvall Williams Advertising

M. J. Crose Mfg. Co., Inc. 228
Paul Locke Advertising, Inc.

Daniel Orifice Fittings Company 192
Darwin H. Clark Company

The Darlington Insulation Company, Ltd. 207
Saward Baker & Company, Ltd.

Dawson & Downie, Ltd. 212
James Jack Advertising Ltd.

Decca Navigator Company, Ltd. 182
John Tait & Partners, Ltd.

De Long Corporation 21
The McCarty Company

Drilling Equipment Mfg. Co. 218
Beals Advertising Agency

Dunlop Rubber Company, Ltd. (Dunlopillo Div.) 213, 238
Bomas Ltd.

E. I. du Pont de Nemours & Company 34-35
(Elastomer Export Dept.)
Batten, Barton, Durstine & Osborn, Inc.

E. C. D. Ltd. 204
KS Advertising Ltd.

Electricdynamic Instruments Corporation 137
Gregory-Giezendanner Company

Esher Wyss Limited 193

Associated Ethyl Company, Ltd. 99

Fish Engineering Corporation 45
Rives, Dyke & Company

Foster Wheeler Corporation 28-29
Arndt, Preston, Chapin, Lamb & Keen, Inc.

Franks Division, Cabot Shops, Inc. 132-133
Advertising Engineers

W. J. Fraser & Company, Ltd. 175
The Technical Advertising Service, Ltd.

Fullers Earth Union, Ltd. 167
Clifford Martin Ltd.

Gardner-Denver Company 44
The Buchen Company

General American Transportation Corporation 50
Edward H. Weiss & Company

General Geophysical Company, Inc. 186
Rives, Dyke & Company

Geo Prospectors, Inc. 184
Wilson Advertising Agency, Inc.

Geolograph Company 246
Lowe Runkle Company

Grill Floors Ltd. 244
J. Peers & Associates Ltd.

Gulf Oil Corporation 183
Ketchum, MacLeod & Grove, Inc.

Halliburton Oil Well Cementing Company 56
Heintz & Company, Inc.

Hammond Iron Works, Inc. 237
Sam J. Gallay, Advertising

Haney and Williams Drilling Company 54
Marian Kress Advertising

Frederic R. Harris, Inc. 248

Herb J. Hawthorne, Inc. 190
Darwin H. Clark Company

Hayward Tyler & Company Ltd. 219

Hercules Tool Company 6
Keefe Advertising Agency

Hewitt-Robins, Inc. 195
Fuller & Smith & Ross, Inc.

Hiller Aircraft Corporation 232
Boland Associates

Holman Brothers Ltd. 20
Samson Clark & Company, Ltd.

F. J. Hone & Company, Ltd. 236
Goffrey Dadd, Ltd.

Horseley Bridge & Thomas Piggott Ltd. 210

Hughes Tool Company 37-38
Foote, Cone & Belding

Imperial Chemical Industries Ltd. 107, 121, 125, 151
Clifford Martin Ltd.

International General Electric Company 30
Grant Advertising, Inc.

International Harvester Export Company 25
McCann-Erickson Corporation (International)

International Standard Electric Corporation 36
J. M. Mathes, Inc.

M. W. Kellogg Company 115
Fuller & Smith & Ross Inc.

Ken Corporation 244
J. W. Christopher Company

Keystone Development Company 248
Darwin H. Clark Company

LaCoste & Romberg 200
Marvin Gwinn & Associates, Inc.

LaFarge Aluminous Cement Company Ltd. 226
Allardyce Palmer Ltd.

Lake & Elliot Ltd. 240
Ripley Preston & Company, Ltd.

Le Grand Rochester Ltd. 242
KS Advertising Ltd.

The London Midland Steel Scaffolding Company Ltd. 181
S. H. Wright & Company, Ltd.

The Lummus Company 2, 7
G. M. Basford Company

Manning, Maxwell & Moore, Inc. 24
Fuller & Smith & Ross Inc.

Martin Decker Corporation 155
Dozier Eastman & Company

McCullough Tool Company 97
Raymond O. Perry, Advertising

Medearis Oil Well Supply Corporation 139
Darwin H. Clark Company

Metaducts Ltd. 225
J. Peers & Associates Ltd.

Metropolitan-Vickers Electrical Company, Ltd. 191
Technical & General Advertising Agency Ltd.

Mexico Refactories Company 40-41
Carl Lawson Advertising Co.

Mid-Continent Supply Company 135
Magnussen Advertising Agency

Milwhite Mud Sales Company 159
Boone & Cummings

Mission Manufacturing Company 55
Rives, Dyke & Company

Motherwell Bridge Contracting & Trading Co., Ltd. 206

National Tank Company 258
Gibbons Advertising Agency, Inc.

Newalls Insulation Company, Ltd. 196-197
Doig Advertising Service

Newman Hender & Company, Ltd. 166
Adams Brothers & Shardlow Ltd.

D. Van Nostrand Company, Inc. 218

Oil Center Tool Company Cover IV
Rives, Dyke & Company

Pacific Pumps, Inc. 27
The McCarty Company

Pacific Valves, Inc. 231
Harold H. Larsen, Advertising

Pan American Petroleum Corporation 95

The Ralph M. Parsons Company Cover III
Dozier Eastman & Company

F. Perkins Limited 122
Crane Publicity Ltd.

Petrolite Corporation 163
Batz, Hodgson Neuwoehner Advertising Agency

Phoenix-Rheinrohr AG 217
Ruhr-Studio

Pipe Line Technologists — *Ulrich Brown Advertising* — 202

Pont-A-Mousson Company — *Rene' d'Auriac* — 11

Porta-Kamp — *Gregory-Giezendanner Company* — 89

The Power-Gas Corporation Ltd. — 1

Procon Incorporated — *Tobias, O'Neil & Gallay, Inc.* — 32

Puutalo Sales Association — 229

W. G. Pye Ltd. — *Arks Publicity Ltd.* — 242

The Pyrene Company Ltd. — *Nelson Advertising Service Ltd.* — 234

Rayflex Exploration Company — *Taylor-Norsworthy, Inc.* — 26

Reed Roller Bit Company — *Rives, Dyke & Company* — 18-19

Rice Hotel — *Ritchie Advertising Agency* — 246

Rockwell Manufacturing Co., International Div. — *Marsteller, Rickard, Gebhardt & Reed Inc.* — 233

Rogers Geophysical Companies — *Rives, Dyke & Company* — 22

Ruston & Hornsby — *Industrial Publicity Service Ltd.* — 215

Sanders & Forster Ltd. — *Stephens Advertising Ltd.* — 208-209

Security Engineering Division (One of the Dresser Industries) — *The McCarty Company of Texas, Inc.* — 127

Siebe Gorman & Company Ltd. — *Technical & General Advertising Agency, Ltd.* — 216

Siemens Edison Swan, Ltd. — *Taylor Advertising, Ltd.* — 245

Sydney Smith & Sons Ltd. — *S. H. Wright & Company, Ltd.* — 187

Socony Mobil Oil Company, Inc. — *Compton Advertising, Inc.* — 13

South Durham Steel & Iron Company, Ltd. — *John Slater Advertising Ltd.* — 179

Peter Spence & Sons Ltd. — *Holmwood Advertising Ltd.* — 223

Standard Oil Company of California — *Batten, Barton, Durstine & Osborn, Inc.* — 205

Standard Oil Company (New Jersey) — *McCann-Erickson, Incorporated* — 170-171

Standard Vacuum Oil Company — *McCann-Erickson Corporation (International)* — 109

Stewart & Stevenson Services, Inc. — *Rives, Dyke & Company* — 211

J. Stone & Company (Charlton) Ltd. — 247

Stone & Webster Engineering Corporation — *Harold Cabot & Company, Inc.* — 100-101

Sun Oil Company — 157

Sun Shipbuilding & Dry Dock Company — *Duremus-Eshleman Company* — 153

Texaco Incorporated — *Cunningham & Walsh, Inc.* — 201

The Thornycroft Organisation — *Gould & Partners Ltd.* — 249

Tileman & Company, Ltd. — *Scott-Turner & Associates, Ltd.* — 147

Union Carbide International Company — *National Export Advertising Service, Inc.* — 16

United Geophysical Corporation — *Dozier Eastman & Company* — 178

United Steel Cos. Ltd. — *Rowlinson Broughton* — 251

Universal Oil Products Company — *Tobias, O'Neil & Gallay, Inc.* — 143-146

Universal Oil Products Co. Products Dept. — *Tobias, O'Neil & Gallay, Inc.* — 23

Vosper Limited — *Wm. Dawson & Sons Ltd.* — 257

Vokes Limited — *Crane Publicity Ltd.* — 238

Welex, Incorporated — *Weekley & Valenti* — 17

West India Shipping Company, Inc. — 161

Westinghouse Electric International Company — 203

Wheaton Brass Works — *Freiwald & Coleman* — 9

Woodfield Hoist & Associated Industries Ltd. — *KS Advertising Ltd.* — 253

Worthington Corporation — *Gotham-Vladimir Advertising, Inc.* — 108

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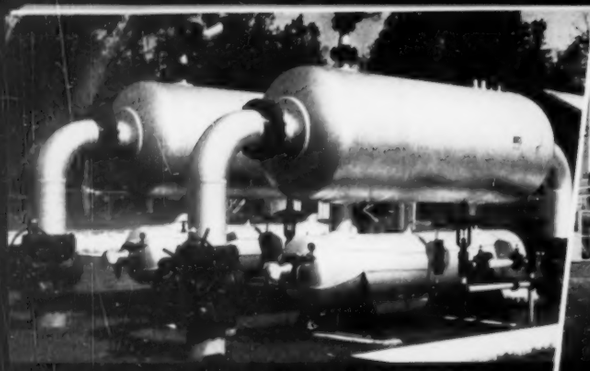

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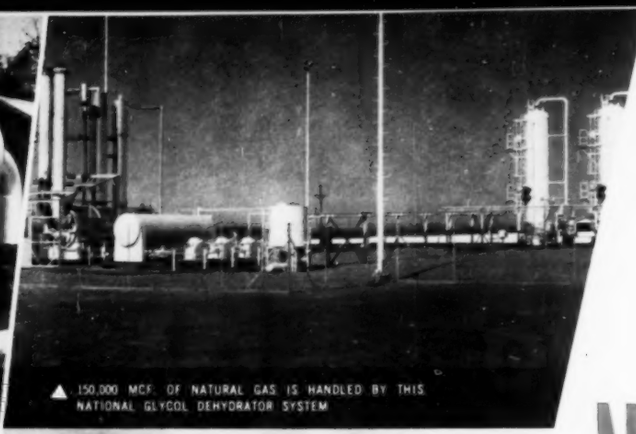

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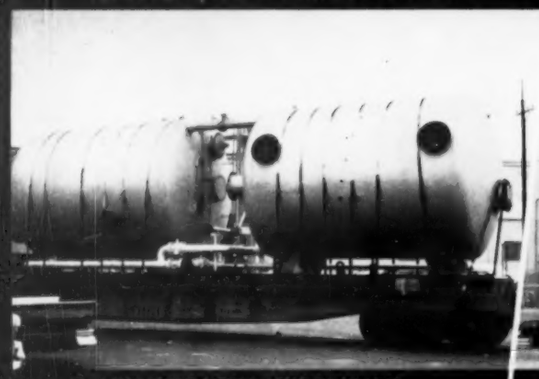

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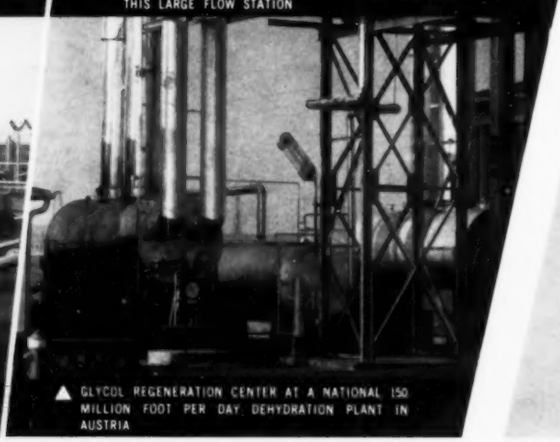
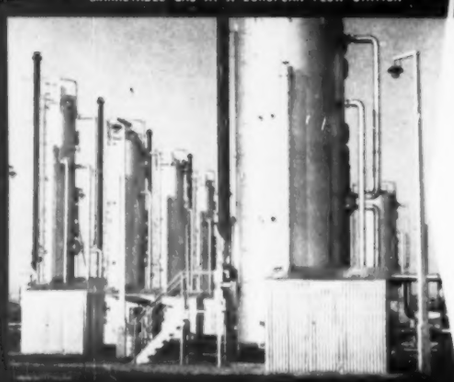
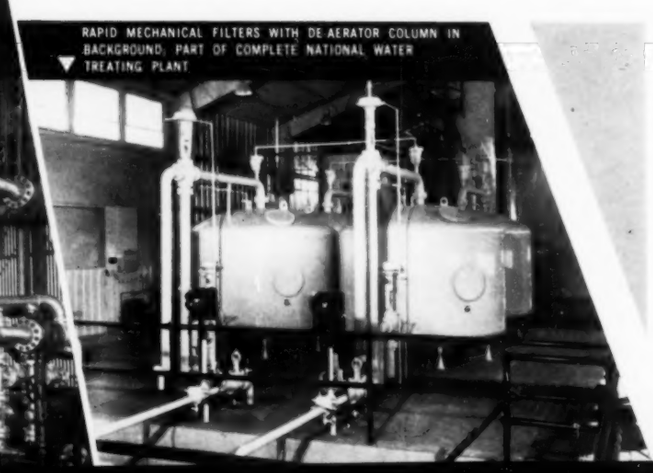


▲ GLYCOL REGENERATION CENTER AT A NATIONAL 150 MILLION FOOT PER DAY DEHYDRATION PLANT IN AUSTRIA



◀ NATIONAL XCP EMULSION TREATERS AT A GATHERING CENTER NORTH OF THE MEDITERRANEAN

▼ COMPLETELY UNITIZED 60" SEPARATION UNIT WITH INLET WELL MANIFOLDING READY FOR SHIPMENT TO VENEZUELA



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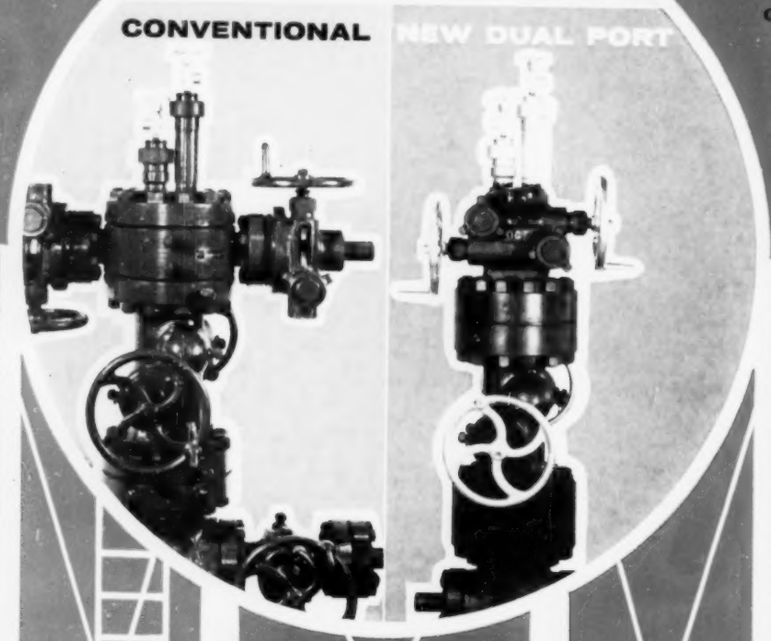

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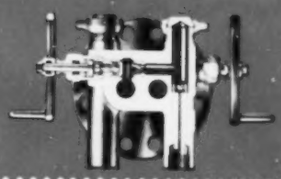

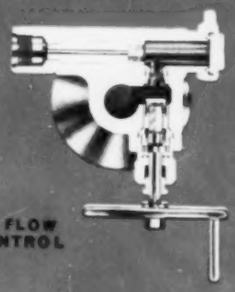

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